PATTERN DRAWING FOR SHEET-METAL WORKERS

By

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EDITOR'S PREFACE

THERE has long been a demand for technical information on the setting out of patterns for the use of the sheet-metal worker. Many books have been produced to meet the demand, and in introducing the latest addition to their number I may say that the present author, Mr. Thomas Newton, has based himself on workshop practice and has succeeded in giving really practical, as distinct from merely theoretical, methods of doing the work. In addition to the chapters on pattern drawing, he has wisely included chapters on joint-making, planishing, annealing, etc., which the practical sheet-metal worker will find valuable. Mr. Newton will be glad to answer through the pages of "Work"—but not by post—any queries relating to pattern drawing and to practical sheet-metal working

B. E. J.

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Pattern Drawing for Sheet-metal Workers

CHAPTER I

What a Sheet-metal Pattern is

EVERY sheet-metal worker has experienced the need for obtaining accurate patterns for the various shapes he is called on to make. In the early days of sheet-metal working it was customary for the walls of a workshop to be covered with bunches of sheet-metal patterns which were assumed to be sufficiently correct for most purposes. Yet these patterns (except for a few stock articles) were practically useless, since they could seldom be utilised for the purposes for which they were kept without involving inaccuracy and waste of material and time. Even to-day there is far too much dependence placed on these workshop patterns which cannot be expected to answer for all purposes.

The ability to draft an accurate pattern for a given article is a technical asset which is reflected in accurate work, the elimination of waste and the saving of both time and labour. The various examples of pattern drawing dealt with in this book represent the solutions of problems which occur in actual daily workshop practice.

What a Sheet-metal Pattern is.—The correct pattern for any given article in sheet-metal is really the de-

velopment of its surface. A development is the unfolding of a surface or, in other words, an exact pattern in the flat which is capable of being bent to the required shape.

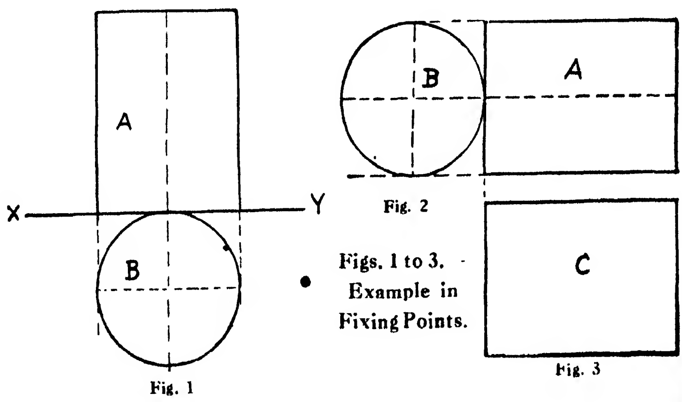
Many different kinds of surfaces are encountered in sheet-metal work, as, for example, plane surfaces, surfaces of single and compound curvature (which curve in more than one direction), surfaces which taper regularly, as well as those which taper irregularly, and combinations or modifications of them all.

The familiar surfaces of the cylinder, cone, pyramid and sphere play an important part in sheet-metal work. A round scoop in its simplest form, for example, is part of a cylinder, just as a cylindrical pipe elbow is nothing more than two mitred cylinders joined together. Similarly a cone, or part of a cone, may be employed as a funnel, a bottle top or a bucket. A portion of a pyramid would serve as a hopper, a hood, or a chute; and a portion of a sphere is often used as a hollowed bottom, or top, or as a lid, or cover.

The Elements of Pattern Drawing.—Before attempting to draw a pattern for a given shape it is advisable, first of all, to understand something about elevations and plans, because in most cases these have to be drawn before a start can be made with the actual drawing of the pattern. Therefore let A (Fig. 1) represent a cylinder standing upright on the base line XY, and let the circle B represent the shape of the cylinder as seen from above; A is then an elevation, and B a plan of the cylinder.

Now let A (Fig. 2) represent an elevation of a cylinder lying on its side. The circle B, which was formerly the plan, now becomes an end elevation; and C (Fig. 3), which is the shape of the cylinder as seen from above, is now the plan.

It will therefore be seen that the position of the cylinder in elevation affects the shape of the plan. An important point to remember is that an end elevation is sometimes used instead of a plan for the purpose of drawing a pattern. This will be readily understood by turning the example shown by Fig. 2 at right angles, for then it becomes essentially the same as the elevation and plan shown by Fig 1.



Figs. 1 to 3. Example in Fixing Points.

It is not always necessary to draw a complete elevation and plan as a preliminary to drawing a pattern. Sometimes an elevation and a half plan is sufficient, and occasionally a half elevation and a quarter plan will suffice.

Fixing Points in Pattern Drawing.—It was previously stated that a simple round scoop is but part of a cylinder. This may be taken as an example to show why an elevation is used in connection with drawing a pattern and to show the reason for its use.

Let A A′ and G G′ (Fig. 4) represent the side elevation of a cylinder, and *a* A′, *b* B′, *c* C′, *d* D′, *e* E′, *f* F′, and *g* G′ the side elevation of a scoop for which a pattern is required. First draw a semicircle on the line A G, using D as a centre, and divide it equally as at 1, 2, 3, 4, and 5. This semicircle may be regarded as a half end-elevation of the cylinder. If the cylinder were turned upright, as in Fig. 1, the semicircle would be a half plan. As the cylinder (Fig. 4) is lying on its side, a half end-elevation is drawn, but if the cylinder were in an upright position a half plan would be necessary. This is explained here in detail in order to make it clear, and also because a correct understanding of the use of these terms is very necessary. Referring again to Fig. 4, dotted lines are drawn parallel with the sides of the cylinder from the points 1, 2, 3, 4, and 5 on the semicircle in order to obtain B B′, C C′, D D′, E E′, F F′, which are points on the side elevation of the cylinder. Incidentally, these dotted lines give a number of points *b*, *c*, *d*, *e*, *f* on the elevation of the curve of the scoop. Having fixed these points on the elevation, it becomes a simple matter to draw the pattern, which may be proceeded with as follows:

Along a straight line A A (Fig. 5) set off twice the number of distances as are contained in the semicircle (Fig. 4), thus making A, B, C, D, E, F, G (Fig. 5) equal to A, 1, 2, 3, 4, 5, G round the semicircle (Fig. 4). The semicircle really represents half the circumference of the cylinder, conse quently twice the number of distances contained in the semicircle must be set off along A A (Fig. 5) to make this represent the complete circumference of the cylinder. A series of parallel dotted lines are now drawn from the points B, C, D, E, F, G on the line A A to cut another series of dotted lines drawn from *a*, *b*, *c*, *d*, *e*, *f*, *g* (Fig. 4) in the points

a, *b*, *c*, *d*, *e*, *f*, *g* (Fig. 5). Now produce, or continue, the line A′ G′ (Fig. 4) to give the line A′ A′ (Fig. 5). A curve is drawn from *a*, passing through *b*, *c*, *d*, *e*, *f*, *g*, *f*, *e*, *d*, *c*,

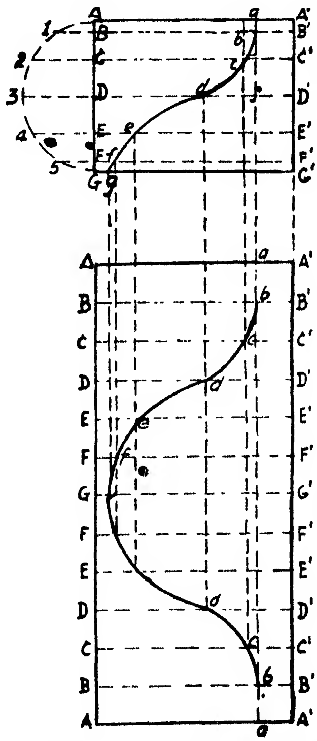


Fig. 4

Fig. 5

Figs. 4 and 5.—Further Example of Point Fixing.

b, *a* to complete the pattern (Fig. 5). It will be noted that the dotted lines which are drawn from the curve of the scoop (Fig. 4) intersect lines which are marked coinci-

dently in Fig. 5. Thus the dotted line drawn from *c* on CC′ (Fig. 4) intersects CC′ (Fig. 5) in the point *c*. Similarly, a dotted line drawn from *d* on D D′ (Fig. 6) intersects D D′ (Fig. 7) in the point *d*, and so on for all the others.

Reverting to Fig. 5, it will be seen that A A′, A A′ represents a pattern for the complete cylinder, and *a* A′, *b* B′, *c* C′, *d* D′, *e* E′, *f* F′, *g* G′, *f* F′, *e* E′, *d* D′, *c* C′, *b* B′, *a* A′ together represent a pattern for the scoop. Whatever working edges may be required for seaming, wiring, etc., must be added to the pattern, and this will also apply to all subsequent patterns, unless otherwise stated.

It will be gathered from the foregoing that the object of using plans and elevations in connection with pattern drawing is simply to fix a number of points, first on the plan or the end elevation, as the case may be, and then on the front or side elevation, from which the pattern may be drawn or projected. It is not always desirable or practicable to project a pattern from an elevation as Fig. 5 is projected from Fig. 4. The pattern may be required on another sheet, in which case the distances are transferred from the elevation to the pattern. Thus the distances, or the lengths of the lines A′*a*, B′*b*, C′*c*, D′*d*, E′*e*, F′*f*, G′G, etc. (Fig. 5), are made equal to those marked similarly in Fig. 4. The only reason for illustrating this projection of a pattern from an elevation is to show in a clearer manner than would otherwise be possible how the example shown by Fig. 4 is developed into that given by Fig. 5. By studying how the lines on different parts of the scoop (Fig. 4) are represented by corresponding lines on the pattern (Fig. 5) a working knowledge of one of the fundamental principles of pattern drawing will thus be obtained.

Instead of attempting to learn by rule how patterns for a few specific articles may be obtained, it is much better

to master the principles involved. These can then also be applied to the solution of uncommon problems. In subsequent chapters it will be shown how patterns for many different shapes may be obtained by the application of these principles.

To give a further example let Fig. 6 represent an elevation of a short piece of round pipe for which a pattern is required. It will be readily seen that the width of this simple pattern is equal to A a, and the length of the pattern is equal to the circumference of the pipe, or $3\frac{1}{7}$ times A G

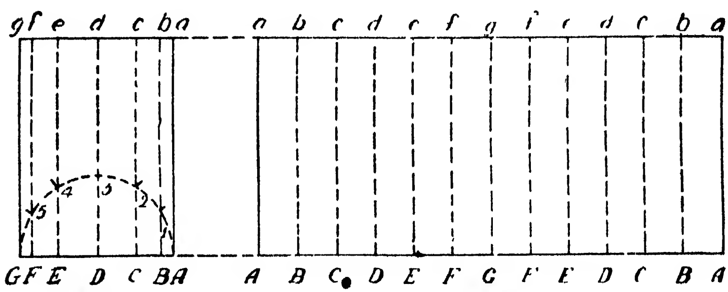


Fig. 6 Fig. 7

Figs. 6 and 7. —Simple Example of Projection.

(Fig. 6). But in pattern drawing—except for the simplest articles—it is more convenient and advantageous to obtain the circumference as follows: First describe a semicircle on A G (Fig. 6), then divide it equally as at 1, 2, 3, 4, 5. Now set the compasses to one of the divisions of the semicircle, and beginning at A (Fig. 7), step off along the straight line A A the distances B, C, D, E, F, G, F, E, D, C, B, A. These distances represent twice the number of divisions that are contained in the semicircle. Obviously twice the number of distances contained in the semicircle equals the circumference, hence A A (Fig. 7) is the circumference of the pipe shown in elevation in Fig 6.

The dotted lines A a, B b, C c, D d, E e, F f, G g (Fig. 7), which are equal in length to those marked similarly in Fig. 6, are not really required in this case, but in other pipe work—as, for example, an elbow—these lines would vary in length, and then they are all-important. Fig. 6 shows that these dotted lines are obtained in their respective places by drawing them through the division points 1, 2, 3, 4, 5 of the semicircle and parallel with the sides of the pipe. We now see by studying Fig. 6 that in the flat or on the pattern (Fig. 7) lines A a and B b are separated from each other by a distance equal to the distance A 1 (Fig. 6) of the semicircle. Similarly, lines B b and C c (Fig. 7) are separated by a distance equal to the distance 1, 2 of the semicircle and so on. Thus the distance on the pattern from A to G is equal to the distance round the semicircle (Fig. 6). The other half of the pattern from G to A (Fig. 7) is, of course, equal to a similar distance round the semicircle. Hence A A (Fig. 7), being equal in length to two semicircles, represents the circumference.

It should be understood that, unless otherwise stated, all working edges, such as allowances for wiring; grooved, riveted, and lap seams; knocked-up and paned-down edges; flanges, etc., are additional to the patterns. These allowances are purposely omitted, since a given shape may be required with a grooved, riveted, or lap seam, as the case may be; it may also be required with or without a wiring edge, and so on: but the important point to remember is to add to the patterns whatever working edges are required.

Awkward Shapes and their Patterns.—Most shapes and surfaces which confront the sheet-metal worker are geometrically developable, but it should be stated that some are not so. A sphere, for example, or any portion

of it, is not strictly developable; and from this it follows that a surface of compound curvature, or, in other words, a surface which curves in more than one direction, cannot be developed theoretically. It is, however, possible to solve such problems by obtaining what may be termed approximations or patterns which are sufficiently correct for all practical purposes. Even in problems such as these the principles previously referred to may be turned to good account, and in some cases they are indispensable.

CHAPTER II

Cylindrical Pipe Work

Elbows, Tees and Junctions.—First draw an elevation of the required elbow, as illustrated by Fig. 8. Now draw the dotted semicircle on the base line, divide it equally as at 1, 2, 3, 4 and 5, and through the points thus obtained draw the dotted vertical lines as indicated, in order to obtain the points A, B, C, D, E, F and G on the base line, and *a*, *b*, *c*, *d*, *e*, *f* and *g* on the mitre line. To set out the patterns, draw the straight line A A (Fig. 9), and step off along it twice the number of distances as are contained in the dotted semicircle (Fig. 8). Thus ABCDEFG (Fig. 9) is equal to A12345G (Fig. 8). A series of vertical lines is now drawn from the points A, B, C, D, E, F and G (Fig. 9), and another series of dotted lines is projected horizontally from *a*, *b*, *c*, *d*, *e*, *f* and *g* (Fig. 8) so as to give *a*, *b*, *c*, *d*, *e*, *f* and *g* (Fig. 9). A curve is now drawn freehand from *a* to *a* (Fig. 9), passing from one dotted line to another in the space of one division, as illustrated. The pattern *aga*AA (Fig. 9) represents the development of *ag*AG (Fig. 8), and the upper portion of Fig. 9 will serve as a pattern for the remaining portion of the elbow (Fig. 8), but in this case one portion of the elbow will have the seam inside, while the other seam will be outside. If, however, both seams are required to be inside (or under the throat of the elbow) both patterns will be represented by *aga*AA (Fig. 9). In the event of both seams being required outside the elbow, both patterns should

be cut similar to the upper portion of Fig. 9. The method of working, as regards obtaining the shape of the patterns,

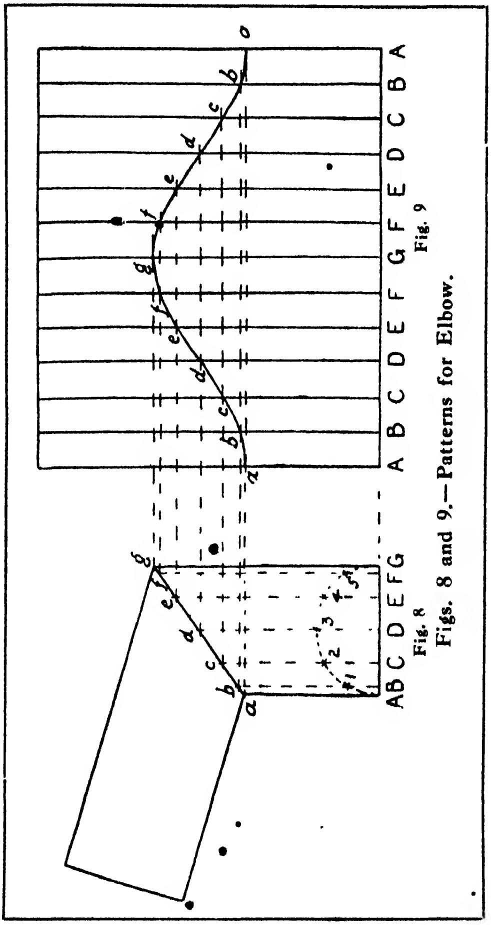


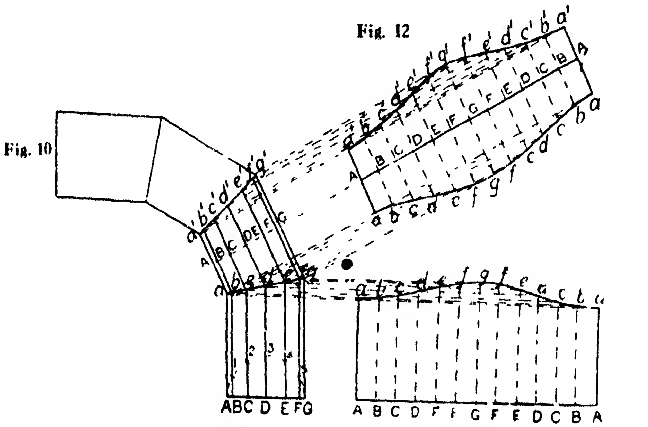
Fig. 9

Fig. 8

Figs. 8 and 9.—Patterns for Elbow.

is applicable also to square elbows, provided that the elevation of a square elbow, instead of an obtuse elbow, is first drawn.

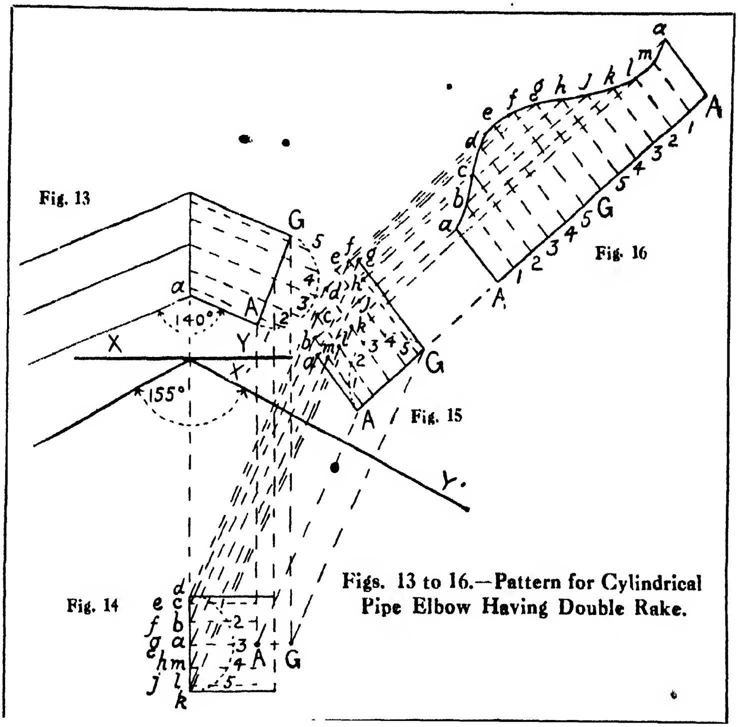
Patterns for Square Elbow in Four Pieces.—Let Fig. 10 represent an elevation of a pipe elbow in four pieces. On referring to the illustration it will be seen that one-half of the elbow is the exact replica of the other, therefore only two patterns will be required. First describe a semicircle on the base line of the elbow, divide it into six equal parts as at 1, 2, 3, 4, and 5, and through the points of division draw the straight lines as indicated, through those two parts which constitute the lower half



Figs. 10 to 12.- Patterns for Square Elbow in Four Pieces.

of the elbow. Now set off along the line AA (Fig. 11) twice the number of divisions that are contained in the semicircle; and through the points of division draw the vertical dotted lines. Dotted lines are projected horizontally from *a*, *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 10), so as to meet the vertical dotted lines in Fig. 11, in order to obtain the points *a*, *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 11). Through the latter

points draw the curved line as indicated, and unite A a with straight lines to complete the pattern. Fig. 12 is obtained similarly, except that the circumferential distances are set off along a central line instead of a base



Figs. 13 to 16.—Pattern for Cylindrical Pipe Elbow Having Double Rake.

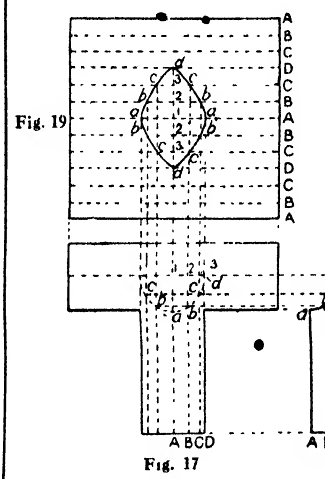
line. Otherwise the same method of procedure is adopted as in the previous example. The illustrations are practically self-explanatory, and the letter references are marked coincidently.

Pattern for Cylindrical Pipe Elbow having Double Rake.—Let Fig. 13 represent an elevation of the elbow,

the two arms of which subtend an angle of 140°. Underneath XY the two lines which subtend an angle of 155° represent the rake of the elbow in plan. First project the plan (Fig. 14) from the elevation (Fig. 13), ignoring for the present the rake of the plan. Describe a semicircle on *dk* (Fig. 14), divide it equally as at 12345, and through these points draw parallel lines in order to obtain *cbaml*. Project A (Fig. 13) to obtain A (Fig. 14). Before the pattern can be drawn, a new elevation must be constructed with certain definite points fixed on it, as shown by Fig. 15. Begin by using X′Y′ (one of the lines which represent the rake of the plan) as a new base line. Now project a series of dotted lines from *dcbamlk*AG (Fig. 14), and at right angles to the new base line X′Y′. Make *a*AG (Fig. 15) the same distance above X′Y′ as are *a*AG above the original base line XY in Fig. 13. Describe a dotted semicircle on AG (Fig. 15), divide it equally as at 12345, and through these points draw a series of parallel lines at right angles to AG so as to intersect the dotted lines projected from Fig. 14. This method of procedure fixes a number of definite points, *abcdefghjklm* (Fig. 15), from which the pattern (Fig. 16) can be drawn. Produce AG (Fig. 15) in order to obtain AA (Fig. 16), and make A12345G (Fig. 16) equal to A12345G (Fig. 15). Now draw at right angles to AA (Fig. 16) a series of dotted lines from the points 12345G, and then project a series of dotted lines from *abcdefghjklm* (Fig. 15) to meet them in the points *abcdefghjklm* (Fig. 16), as illustrated. A curve drawn from *a* to *a* (Fig. 16), passing through the points thus obtained, completes the pattern. There is no need to develop the other arm of the elbow, since one pattern will serve for both. The problem is somewhat complicated on

account of the double rake, but the coincident marking of the letter references in all the figures should render the method of working abundantly clear, provided a little careful study is devoted to the text and illustrations.

Patterns for T-piece.—Let Fig. 17 represent the T-piece for which patterns are required. First describe the dotted semicircle from the centre 1 (Fig. 17), and divide it equally



Figs. 17 to 19.—Patterns for T-piece.

as at *a*, *b*, *c*, and *d*. To set out the pattern for the lower limb, step off the twelve distances along the line A A (Fig. 18), making each distance equal to one of the distances (say *a b*) of the dotted semicircle in Fig. 17. A series of dotted vertical lines is drawn from A, B, C, and D (Fig. 18), as illustrated, then another series of dotted horizontal lines is projected from *a*, *b*, *c*, and *d* (Fig. 17) to cut the dotted vertical lines of Fig. 18 respectively, as at *a*, *b*, *c*, and *d*. A curve drawn through the points thus obtained completes

the pattern. A pattern for the cross part of the **T** is shown by Fig. 19, where the circumference of the pipe is repre-

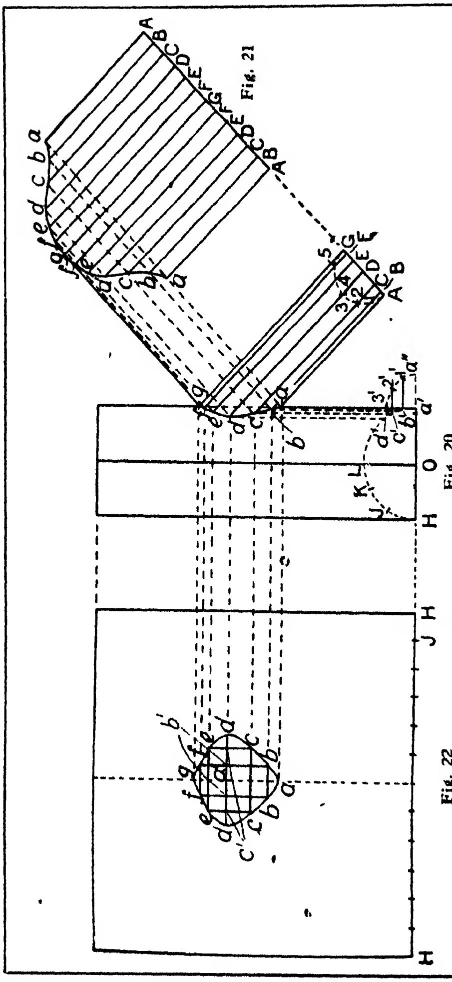


Fig. 21

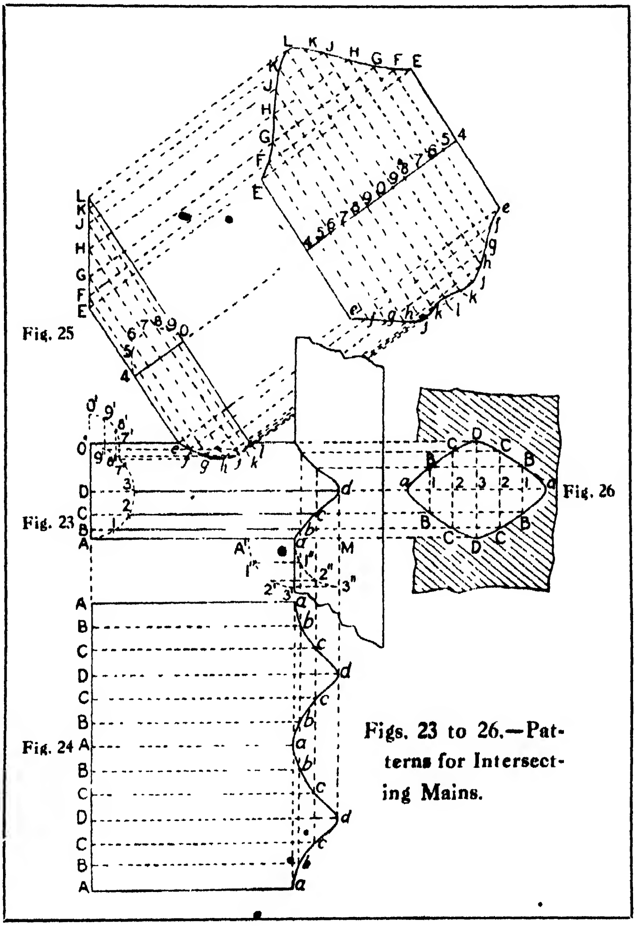
Fig. 20

Fig. 22

Figs. 20 to 22.—Patterns for Unequal Slanting Junction Pipe.

sented by A A, the twelve divisions being stepped off as in the former case. A series of dotted horizontal lines

is drawn from the points of division, and then another series of dotted lines is projected vertically from *a*, *b*, *c*,



Figs. 23 to 26.—Patterns for Intersecting Mains.

and *d* (Fig. 17) to cut them respectively in the points *a*, *b*, *c*, and *d* (Fig. 19), as indicated. A curve drawn to pass through the points thus obtained gives the exact

shape of the hole of penetration, which may be cut, if desired, before the pipe is bent to shape. The method herewith described is applicable to equal tees of all sizes and diameters.

Patterns for Unequal Slanting Junction Pipe.—Let Fig. 20 represent an elevation of the junction, intersecting a larger main pipe. First describe a semicircle on the line A G (Fig. 20), divide it equally as at 1, 2, 3, 4 and 5, and through the points of division draw lines parallel with the sides of the pipe as illustrated. With O as centre

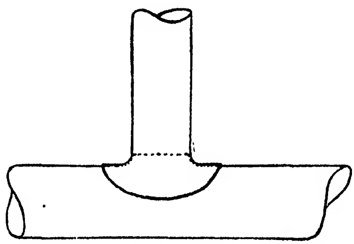
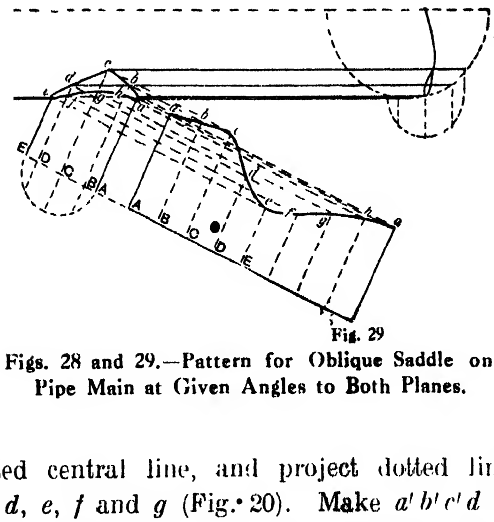


Fig. 27.—Saddle Joint on Pipe.

draw a semicircle on the main pipe; with a' (Fig. 20) as centre, and radius equal to that of the junction semicircle A D, describe the arc $3' a''$. Divide the latter arc equally as at $1'$ and $2'$, and from these points draw lines parallel with $a' a''$ so as to obtain the points d', c' and b' on the main semicircle. Lines are now drawn from the latter points to meet those respectively on the junction, in the points b, c, d, e, and f. Thus a line drawn from C meets the one drawn from c' in the point c, and so on. To draw the pattern (Fig. 21), step off along the line A A twice the number of divisions that are contained in the junction semicircle, and through the points of division draw lines at right angles to A A to meet those drawn respectively

from *a*, *b*, *c*, *d*, *e*, *f* and *g* (Fig. 20). Thus a line projected from *c* (Fig. 20) meets the one drawn from C (Fig. 21) in the point *c* (Fig. 21), and so on. A line now drawn from *a* to *a* through the points *b*, *c*, *d*, *e*, *f* and *g* (Fig. 21) completes the pattern for the junction pipe. To obtain the shape of the hole of intersection, make H H (Fig. 22) equal to the circumference of the main pipe, by stepping off twelve divisions, each equal to H J (Fig. 20). Draw



Figs. 28 and 29.—Pattern for Oblique Saddle on Pipe Main at Given Angles to Both Planes.

the dotted central line, and project dotted lines from *a*, *b*, *c*, *d*, *e*, *f* and *g* (Fig. 20). Make $a' b' c' d$ (Fig. 22) equal to the arc $a' b' c' d'$ (Fig. 20), and draw lines through the points thus obtained, parallel with the central line (Fig. 22), to meet the projected dotted lines in the points *a*, *b*, *c*, *d*, *e*, *f* and *g*. A curve drawn to pass through the latter points gives the shape required.

Patterns for Intersecting Mains.—Let Fig. 23 re-

present the main connections, comprising an equal **T**-piece and a smaller branch pipe inclined to the **T**-piece and having a bevelled end. To obtain a pattern for the **T**-piece first obtain an elevation of the junction line, as follows: With D (Fig. 23) as centre, describe a semicircle, which divide equally as at 1, 2, and 3, and through the points of division draw lines parallel to the sides of the pipe. With M as centre and M*a* as radius, describe the arc *a* 3″; similarly, with *a* as centre and DA as radius, describe the arc A′3′; divide it equally as at 1′ and 2′, and from the latter points draw dotted lines to obtain 1″, 2″, and 3″ on the other arc, as indicated. Dotted lines are now projected from the points thus obtained to cut the parallel lines in the points *b*, *c*, and *d*, as shown, and a curve drawn to pass through the latter points gives the true shape of the junction line. To draw the pattern (Fig. 24), set the compasses to one of the divisions of the semicircle as at A 1 (Fig. 23) and along the line AA (Fig. 24) step off twelve divisions. Lines are now drawn through the points thus obtained to cut the dotted lines which are drawn from *a*, *b*, *c*, and *d* on the junction line (Fig. 23), in order to obtain *a*, *b* *c*, and *d* (Fig. 24), and a curve drawn to pass through the latter points completes the pattern. A pattern for the inclined and bevelled branch pipe (Fig. 23) is shown by Fig. 25; but before attempting to set out the pattern the junction line must first be obtained as in the former case. Thus the semicircle in the centre of the branch is equally divided, and parallel lines are drawn through the points of division. The arc 7′*o*′ equals half the semicircle. Dotted lines are drawn from 7′, 8′, 9′ and *o*′ to give 7″, 8″, 9″, and *o*″ on the larger semicircle at the base of the tee, and from these latter points dotted lines are projected to meet respectively those

parallel lines which pass through coincident numbers. A curve drawn to pass through *e*, *f*, *g*, *h*, *j*, *k* and *l* (the points thus obtained) gives a true elevation of the junction. From this stage onwards the pattern becomes self-explanatory; but it should be noted that the distances along the central line of Fig. 25 are equal to twice the number of those contained in the branch semicircle (Fig. 23). The shape of the hole of penetration for the **T**-piece, is shown in Fig. 26, where *a* 1 2 3 equals *a* 1″ 2″ 3″ (Fig. 23). Similarly B1 C2 D3 (Fig. 26) are equal to B1 C2 D3 (Fig. 23), and a curve drawn to pass through the points thus obtained gives the true shape of the hole required. It may be stated that any deviation from the shapes of the junction lines, as illustrated, can only be made at the expense of cylindrical accuracy.

Making Saddle-joint on Pipe.—A saddle-joint is so called because one pipe (the branch) is made to fit another (the main), somewhat like a saddle fits a horse. In Fig. 27 it will be seen that one end of the branch pipe is flanged outwardly to fit the main pipe, and before this can be done it will be necessary to anneal the pipe, probably two or three times. The pipe may be annealed by heating it to a dull red and then allowing it to cool down of its own accord in the absence of cooling draughts of air. The flanging process should be carried as far as possible, namely, until the metal offers a decidedly greater resistance to working, after which it should be annealed again. This method of working should be repeated until the branch pipe satisfactorily fits the main pipe. When flanging the pipe, start round the outer edge, and gradually work away from it. It will, however, be necessary to return to the edge from time to time in order to stretch it sufficiently to obtain the flange. Do not continue work-

ing the metal when it becomes "hard" or brittle, otherwise it will probably crack, and spoil the job. It is much better to anneal it periodically. The hole in the main pipe should be made small to begin with, and the metal in the vicinity of the hole should be annealed so as to facilitate its being worked in an outward direction until it fits the saddle of the branch joint, as illustrated by the dotted lines. The branch is then fixed in position and secured by a couple of rings of fine iron wire, each ring of wire being twisted so as to pull the saddle well home ready for brazing.

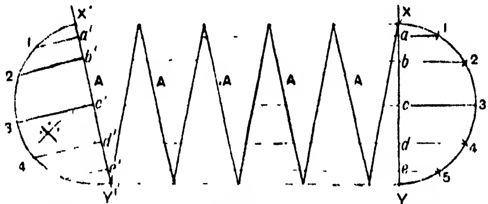


Fig. 32 Fig. 30 Fig. 31

Figs. 30 to 32.—Pattern of Worm for Shaft.

Pattern for Oblique Saddle on Pipe Main at Given Angles to Both Planes.—First draw an elevation of the pipe main (Fig. 28), showing the inclination of the saddle in one direction, as at A *a* E *e*. At the end of the main draw the dotted semicircles equal respectively to the sizes of the main and saddle, to give the other inclination as indicated. On the line A E (Fig. 28) describe a semicircle, which divide in four equal parts, and from the points of division draw lines at right angles to A E. Similarly divide the smaller semicircle at the end of the main, and from the points thus obtained draw lines at right angles to the sides of the main until they touch the larger semicircle. Then from these points draw lines parallel to the

sides of the main, to meet those previously drawn on the saddle in order to obtain the points *a*, *b*, *c*, *d*, *e*, *f*, *g*, and *h*. A curve drawn through these points gives the curve of intersection, from which the pattern may be obtained. To draw the pattern (Fig. 29) set off twice the number of distances that are contained in the semicircle of the saddle (Fig. 28), along the line A A, and from the

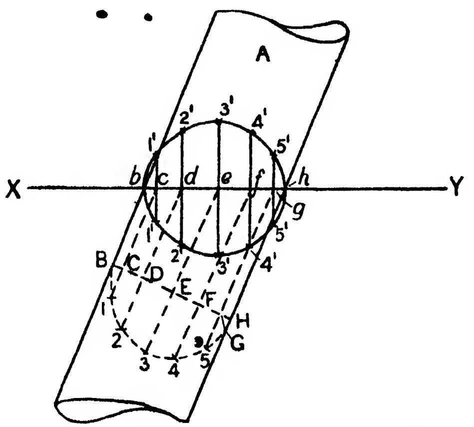


Fig. 33.- Shape of Hole for Inclined Pipe.

points draw the vertical dotted lines as illustrated. Now from the points *a*, *b*, *c*, *d*, *e*, *f*, *g*, and *h*, on the intersection curve (Fig. 28), project the dotted lines at right angles to A *a*, until they touch the vertical lines marked coincidently. Then A *a*, B *b*, C *c*, etc. (Fig. 28) will equal A *a*, B *b*, C *c*, etc. (Fig. 29), and a curve drawn through the points gives the required pattern.

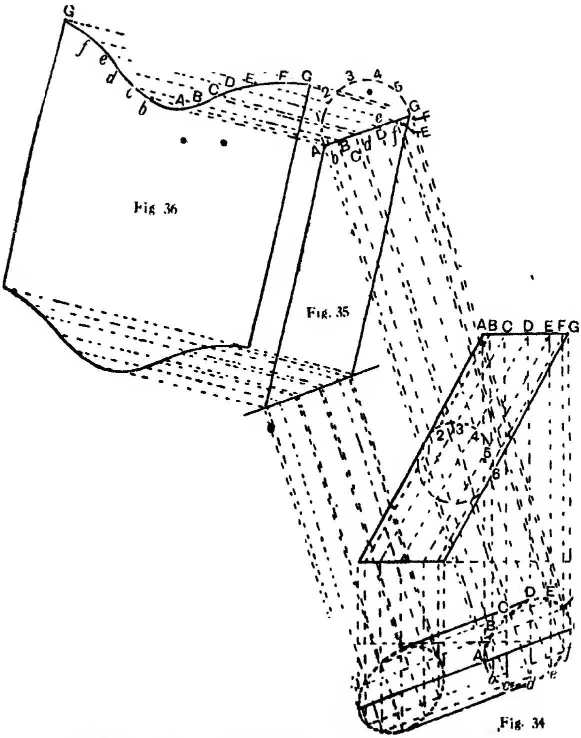
Pattern of Worm for Shaft.—Let A (Fig. 30) represent the worm, drawn to the desired size and pitch, for which

a pattern is required. The shape of the pattern will be an ellipse, owing to the pitch of the blades A, which may be regarded as a series of ellipses lying in a cylinder as indicated. To obtain the pattern, first draw Fig. 31, which is a semicircle, with *c* as centre and *c* X as radius, and divide it into any number of equal parts as at 1, 2, 3, 4, 5. From these points draw lines at right angles to X Y, giving the points *a*, *b*, *c*, *d*, *e*, and produce the lines to give *a*′, *b*′, *c*′, *d*′, *e*′, on the line X′Y′ (Fig. 32), which is one of the blades. Now draw lines from the points of division on the line X′Y′, and at right angles to it, and make *a*′1 equal to *a*1 (Fig. 31). Similarly transfer the lengths *b*2, *c*3, *d*4, *e*5 (Fig. 31), to those marked coincidently in Fig. 32, and draw a curve from X′ to Y′ to touch the ends of the lines as illustrated. This will be a half pattern for one of the blades, which are made in halves, but lap for seam must be additionally allowed. The central hole to fit the shaft is not drawn (to avoid confusion), but it is obtained in precisely the same way as described above.

Shape of Hole for Inclined Pipe. Let A, in Fig. 33, represent a pipe passing through the plane X Y at a given angle. On a line B H, drawn at right angles to the sides of the pipe, describe a semicircle, which divide equally as at 1, 2, 3, 4, and 5. From these points of division draw the dotted lines as indicated, in order to obtain the points C, D, E, F, and G, and *c*, *d*, *e*, *f*, and *g*. Through these latter points draw lines at right angles to X Y, and make *c* *d*2′, *e*3′, *f*4′, *g*5′, on each side of the line X Y, equal respectively to C1, D2, E3, F4, and G5. A curve drawn to pass through the points thus obtained gives the shape of hole required.

Development of Oblique Cylinder Inclined to Both the Horizontal and Vertical Planes.—Let Fig. 34 re-

present an elevation and plan of the cylinder under consideration. First describe a circle (as shown in the elevation), divide it equally as at 1, 2, 3, 4, 5, and 6, and through



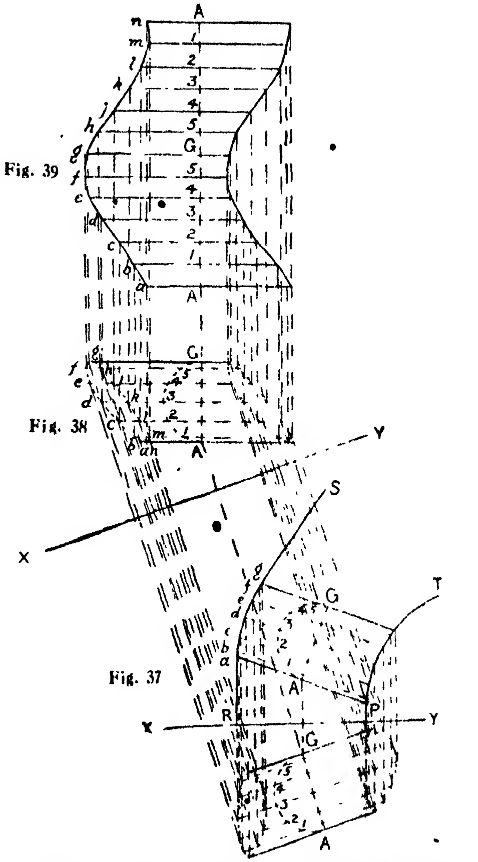
Figs. 34 to 36. Development of Oblique Cylinder.

the points thus obtained draw dotted lines parallel with the sides of the cylinder so as to give A, B, C, D, E, F, and G

at the top of the cylinder (Fig. 34). Dotted perpendicular lines are now dropped from these latter points to the plan, which, on account of its inclination to the vertical plane, yield the points A, B, C, D, E, F, G, *f*, *e*, *d*, *c*, *b*, and *a*, and from these points and those at the other end of the plan a new elevation (Fig. 35) is projected, the base line being parallel with the central line of the plan. The illustration now becomes practically self-explanatory. Lines are drawn from the points in the new elevation, at right angles to the side of the cylinder, and one of the divisions of the semicircle on A G (Fig. 35) is used as a measurement in stepping off the distances from G to G (Fig. 36). Although the problem is somewhat complicated, it will readily be grasped by following the progress of the lines from the original elevation first to the plan, then to the new elevation, afterwards to the development (Fig. 36). Thus the line B becomes B, and also *b* in the plan. Then both B and *b* are projected to the new elevation (Fig. 35), from whence dotted lines are projected across to the development, and these terminate in B and *b* (Fig. 36). The other end of the cylinder is similarly dealt with as indicated.

Pattern for Oblique Pipe for Uptake.—The sketch (Fig. 37) shows a pipe passing through an uptake at an inclination to both the horizontal and vertical planes, and as the contour of the uptake is curved where the pipe passes through it, the problem is fairly complicated. However, let R S P T (Fig. 37) represent the uptake showing an elevation of the pipe passing through it. First divide it equally as at 1 2 3 4 5, then draw parallel lines through the points of division, as illustrated, in order to obtain a series of points at each end of the pipe, such as those marked *a*, *b*, *c*, *d*, *e*, *f*, *g* at one end. It now becomes possible to draw the plan of the pipe, and this is illustrated under

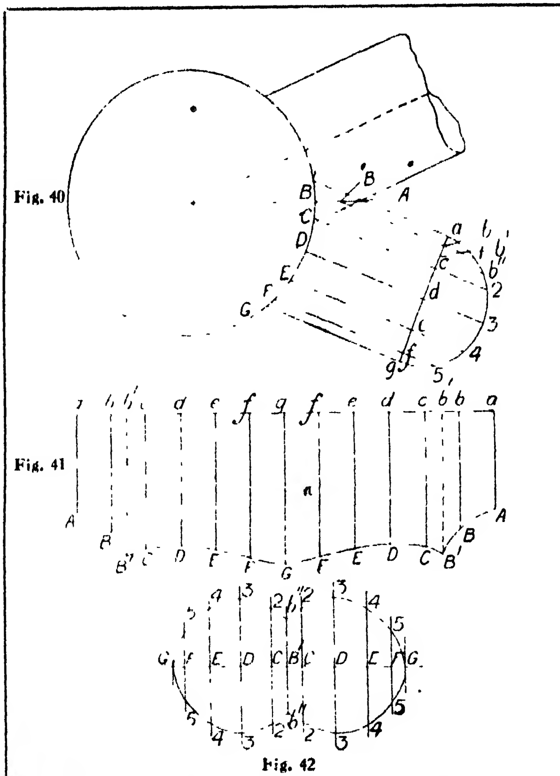
the base XY (Fig. 37). A series of lines are projected from each end of the pipe in elevation, to cut a series of lines



Figs. 37 to 39.—Pattern for Oblique Pipe for Uptake.

drawn at right angles to GA in plan, in order to obtain the points shown at each end of the pipe in plan. Thus

the elevation shows one inclination of the pipe, and the plan the other. Before the pattern can be drawn, a new elevation must be projected, as illustrated by Fig. 38. The chief thing to remember in this connection is that



Figs. 40 to 42.—Patterns for Twin Tee-piece.

the pipe must be the same distance above XY in Fig. 38 as it is above XY in Fig. 37. Of course XY (Fig. 38) must be drawn parallel to the sides of the pipe in plan. Having now a series of points fixed at each end of the pipe in

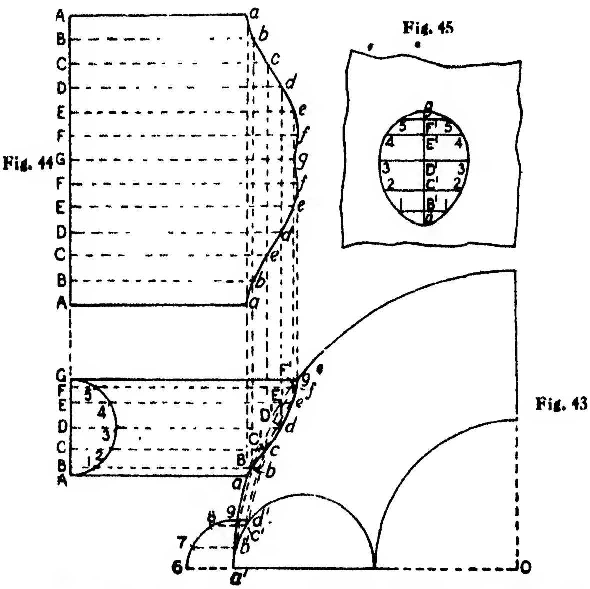
Fig. 38, the pattern can be drawn as illustrated in Fig. 39. Set off along the line A A (Fig. 39) the distances A 1 2 3 4 5 G, making them equal to the distances marked similarly in the semicircle in Fig. 38. A series of dotted lines are now projected from each end of the pipe (Fig. 38) to cut a series of lines drawn through the points A, 1, 2, 3, 4, 5, and G (Fig. 39). A series of points are thus obtained at each end of the pattern, such as those marked *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *j*, *k*, *l*, *m*, and *n* at one end, as illustrated. And curves drawn to pass through these points complete the pattern. The illustrations are practically self-explanatory as far as it is possible to make them; and they may be readily followed by remembering that the object is to project a series of points from the elevation to the plan (Fig. 37), thence to a new elevation (Fig. 38), and finally to the pattern (Fig. 39).

Patterns for Twin Tee-Piece.—Fig. 40 represents a plan of two smaller cylinders intersecting a larger one as indicated. Developments are required for all three. It will be noted that the smaller cylinders are practically identical, so that only one pattern will be required; but the plates must be bent in opposite directions to ensure a perfect fit at the joint B′ A.

On the line *a g* (Fig. 40) describe a semicircle, divide it into a number of equal parts as at 1, 2, 3, 4, 5, and from the points of division draw parallel lines to obtain the lengths G *g*, F *f*, E *e*, etc.

Then along *a a* (Fig. 41) set off twice the number of distances that are contained in the semicircle *a* 3 *g* (Fig. 40), so that *a b* represents *a* 1 on the semicircle, and so on. The lengths of the lines A *a*, B *b*, B′ *b′*, C *c*, D *d*, E *e*, F *f*, and G *g* (Fig. 41) are transferred from those marked coincidently in Fig. 40, and a curve is then drawn from A to A to complete the pattern.

The shape of the hole in the larger cylinder is represented in Fig. 42, where the distances B′, C, D, E, F, G are equal to B′ C, D, E, F, G in Fig. 40. Make B′ b'', C2, D3, E4, and F5 (Fig. 42) equal respectively $b'b''$, $c2$, $d3$, $e4$, and $f5$ (Fig. 40), and finally draw a curve through the points that have been thus obtained.



Figs. 43 to 45.—Pattern for Branch Pipe Intersecting Bend.

Pattern for Branch Pipe Intersecting Bend.—Let Fig. 43 represent an elevation of the bend and branch pipe for which a pattern is required. To obtain first an elevation of the junction a to g, describe a semicircle on the line A G, divide it equally as at 1, 2, 3, 4, and 5, and draw the

dotted lines through the points of division as indicated. Now draw a semicircle on the base line of the bend, and with a' as centre draw the quadrant $a'69$, making it equal to half the semicircle A G 3 (Fig. 43). Divide the quadrant equally as at 7 and 8, and from the four points on the quadrant draw dotted lines parallel with the base line to cut the semicircle on the base of the bend in the points a', b', c', and d'. Now with O as centre, draw a series of dotted arcs from the latter points to cut respectively the dotted lines of the branch pipe in the points a, b, c, d, e, f, and g. A curve drawn to pass through these points gives the junction line required, without which the branch pipe cannot be properly developed, nor the shape of the hole set out. To obtain the pattern (Fig. 44), step off along the line A A twice the number of distances that are contained in the branch semicircle, and from the points thus obtained draw a series of dotted lines as illustrated. Another series of dotted lines are now projected from the points of the junction line (Fig. 43), to cut those marked coincidently in Fig. 44, and a curve is drawn to pass through the points thus obtained to complete the pattern. The shape of the hole is given in Fig. 45, where a B′ C′ D′ E′ F′ g equals a B′ C′ D′ E′ F′ g (Fig. 43). Make B′1, C′2, D′3, E′4, and F′5 (Fig. 45) equal to B 1, C 2, D 3, E 4, and F 5 (Fig. 43), and draw a curve through the points thus obtained to give the shape of the hole required.

Bends, Ventilators and Cowls: Making Quadrant Bend in Segments.—A simple quarter bend is here described to illustrate the principle; but a double bend such as swan-neck, or a U-bend, may be set out similarly. First draw an elevation of the bend (whatever the shape may be) as at A G J J′ (Fig. 46). Divide the outer arc into a number of equal parts as at A′ H I, and from

these points of division draw radial lines to O, as indicated. On the line A G describe a semicircle, divide it into a number of equal parts as at 1, 2, 3, 4, and 5, and from those points draw lines at right angles to A G, to obtain the points B, C, D, E, F; then with O as centre, and radii equal respectively to O B, O C, etc., draw arcs in order to obtain B′, C′, D′, E′, F′, and unite A A′, B B′, C C′, etc., with straight lines. Now along

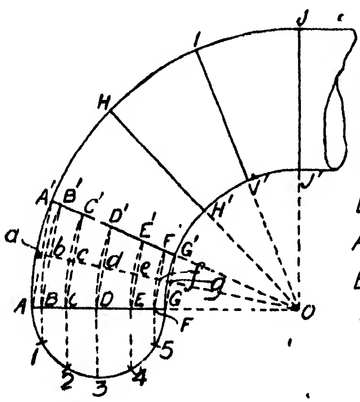


Fig. 46

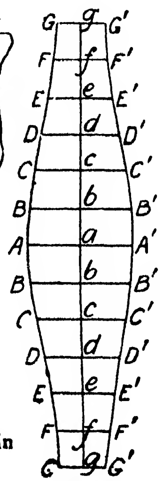


Fig. 47

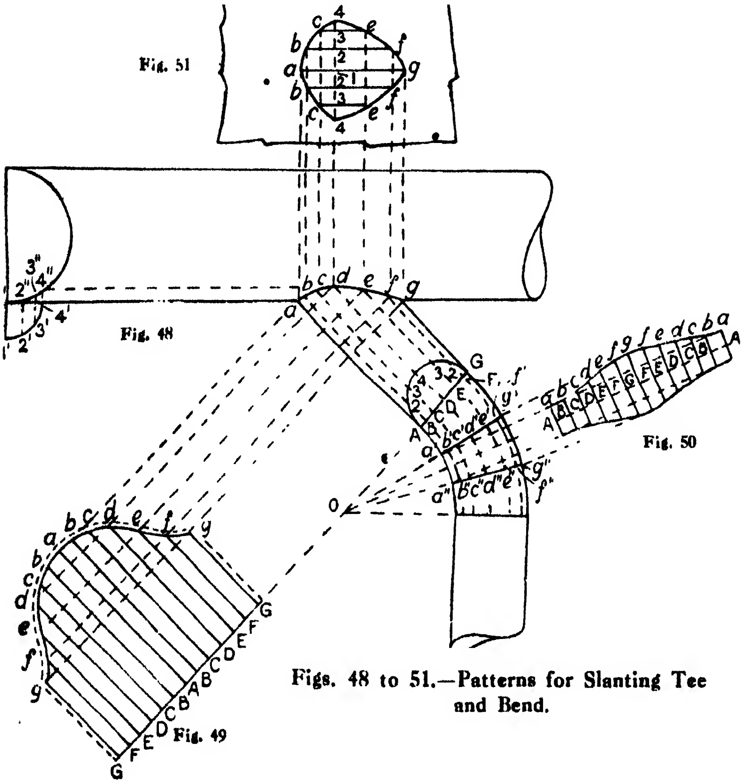
Figs. 46 and 47.—Quadrant Bend in Segments.

a straight line (Fig. 47) set off *a b c d e f g*, twice the number of divisions that are contained in the semicircle A 3 G (Fig. 46). Transfer the lengths A A′, B B′, C C′, D D′, E E′, F F′, and G G′ from Fig. 46 to Fig. 47, and draw curves through the points thus obtained to complete the pattern. As the segments of the bend are equal, one pattern will suffice. The bend may be made of any number of segments; but one of them at least should be drawn in elevation for the pur-

pose of obtaining the pattern. It should be remembered that when few segments compose the bend, the latter does not possess the roundness which a greater number of segments impart to it. The segments should now be slightly hollowed, in pairs if possible, and then bent to shape, after which they are soldered or riveted together; but a lap allowance must be added to the pattern for that purpose.

Patterns for Slanting Tee and Bend.—Let Fig. 48 represent a side elevation of the main pipe, slanting tee, and bend required. First describe a semicircle on the line A G, divide it equally as at 2, 3, and 4; then draw dotted lines through these points, parallel with the sides of the pipe. With the same radius, draw the quarter circle 1′ 4′ at the end of the main pipe, divide it equally as at 2′ and 3′, then draw the short straight lines from 2′, 3′, and 4′ at right angles to the sides of the pipe, so as to obtain 2″, 3″, and 4″ on the main pipe semicircle. A series of dotted lines are now drawn from the latter points, parallel with the sides of the main pipe, to cut those previously drawn parallel with the sides of the branch pipe, in order to obtain *b*, *c*, *d*, *e*, and *f* on the junction curve. Thus, the line from 4″ cuts *d*, similarly the line from 3″ cuts *c* and *e*, while the line from 2″ cuts *b* and *f*. To draw Fig. 49, a pattern for the branch pipe, project a line from A G (Fig. 48), then step along it twice the number of distances that are contained in the semicircle A 4 G (Fig. 48), as at G, F, E, D, C, B, and A (Fig. 49). From these points draw a series of lines at right angles to G G (Fig. 49). Another series of lines are now projected from *a*, *b*, *c*, *d*, *e*, *f*, and *g* on the junction line of Fig. 48, to cut the former lines coincidently, as at *a*, *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 49), as illustrated. A curve drawn from *g* to *g*, passing through the points thus obtained, completes the pattern. The dotted lines of the pattern (Fig. 49) represent the work-

ing edges for a grooved seam, and the desired edge for the main pipe. On referring to Fig. 48 it will be seen that the bend is composed of three equal segments, a pattern for one



Figs. 48 to 51.—Patterns for Slanting Tee and Bend.

of which is shown at Fig. 50. With O (Fig. 48) as centre, draw a series of arcs from A, B, C, D, E, F, and G in order to obtain a', b', c', d', e', f', and g' and a'', b'', c'', d'', e'', f'', and g'' on the central segment. Now draw a line A A (Fig. 50)

consisting of twice the number of divisions that are contained in the branch semicircle A 4 G (Fig. 48), and through the division points B, C, D, E, F, and G (Fig. 50) draw the short lines at right angles to the central line. A series of dotted lines are now drawn as indicated from a', b', c', d', e', f', and g' (Fig. 48) to cut those marked coincidently in Fig. 50. Similarly, another series are drawn from a'', b'', c'', d'', e'', f'', and g'' (Fig. 48). Curves are now drawn to pass through the points thus obtained to complete the pattern (Fig. 50). Working edges in this case must be added to the pattern. A pattern for the shape of the hole in the main pipe is shown in Fig. 51, where the distances 1, 2, 3, and 4 on the line projected from *d* (Fig. 48) are equal to the distances $1''$, $2''$, $3''$, and $4''$ in the main pipe semicircle (Fig. 48). Short straight lines are drawn through the points 1, 2, and 3 (Fig. 51) at right angles to 4 4. A series of dotted lines are now projected from *a*, *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 48) to cut these short straight lines, as indicated, in the points *a*, *b*, *c*, *e*, *f*, and *g* (Fig. 51). A curve drawn through the points thus obtained gives the shape of the required hole.

Pattern for Segment of Tapering Bend.—Fig. 52 represents a tapering bend made up of three segments. One end of the bend is to fit on P, a pipe 3 ft. in diameter, while the other end fits inside a pipe L 2 ft. 6 in. in diameter. A separate pattern for each segment will be required, as no two segments are alike. With reference to the central one, a method of obtaining the pattern is to bisect the arc *a a'* in the point A, and the arc *g g'* to give the point G. Join A and G by a straight line, and describe the dotted semicircle, which divide into a number of equal parts as at 1, 2, 3, 4, and 5. From these points draw the dotted lines at right angles to A G to give the points B, C, D, E, and F. Unite *a a'* by a straight line, and through the points B, C, D, E, and F

draw other straight lines parallel to $a\,a'$, in order to obtain the points $b\,b'$, $c\,c'$, $d\,d'$, $e\,e'$, $f\,f'$, and $g\,g'$. In this case the lines $a\,a'$ and $b\,b'$ are practically coincident. To set out the pattern, draw A′ G′ a straight line, and along it mark the distances B′, C′, D′, E′, and F′, making each of them equal to the distance 2 3 on the dotted semicircle. Through A′ draw

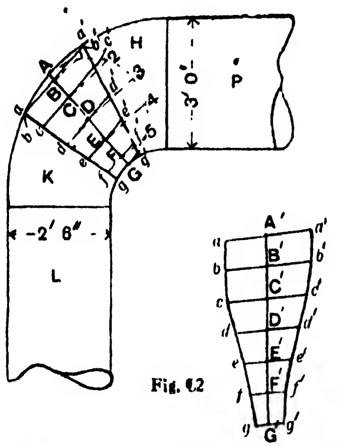
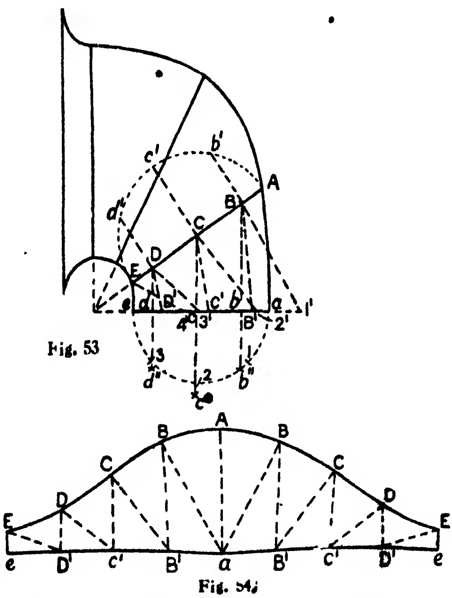


Fig. 52.—Pattern for Segment of Tapering Bend.

$a\,a'$, at the same angle to A′ G′ as $a\,a'$ is to A G in elevation. Now through the points B′, C′, D′, E′, F′, and G′ draw straight lines parallel to $a\,a'$, and make A′ $a\,a'$, B′ $b\,b'$, C′ $c\,c'$, D′ $d\,d'$, etc., equal respectively to A $a\,a'$, B $b\,b'$, C $c\,c'$, D $d\,d'$, etc. A curve drawn through the points thus obtained on each side of the central line of the pattern completes one-half of it. The other half of the pattern is identical. Separate patterns for the segments H and K may be obtained similarly. No patterns are shown for the parts P and L, as these are simply

round pipes. The seams should come under the throat of the bend.

Pattern for Segment of Ship's Ventilator.—Let Fig. 53 represent an elevation of a ventilator in three segments. To obtain a pattern for the lower segment E A *e a*, first describe



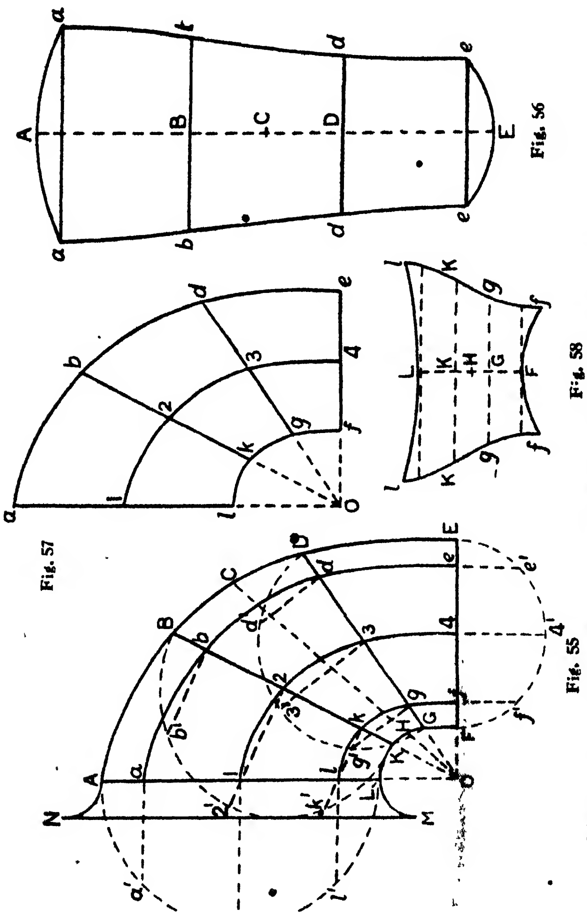
Figs. 53 and 54.—Pattern for Segment of Ship's Ventilator.

semicircles on the lines E A and *e a*, which divide equally as at 1, 2, 3, and *b'*, *c'*, and *d'*. Draw dotted lines from *b'*, *c'*, and *d'* at right angles with A E to give B, C, and D, and from these latter points draw dotted lines at right angles with *a e*, in order to obtain the points *b*, *c*, and *d*. Make *b b''*,

$c c''$, and $d d''$ equal respectively to B b', C c', and D d'. Set off $b\,1'$ equal to $a\,b''$, and b B$'$ equal to $b''\,1$, and unite both to B with dotted lines. Set off $c\,2'$ equal to $1\,c''$, and c C$'$ equal to $c''\,2$, and unite both to C similarly. Set off $d\,3'$ equal to $2\,d''$, and d D$'$ equal to $d''\,3$, and unite them to D. Finally set off $e\,4'$ equal to $e\,3$, and unite $4'$ to E. To draw the pattern (Fig. 54), make A a equal to A a (Fig. 53), make A B and a B$'$. (Fig. 54) equal respectively to A b' and $a\,1'$ (Fig. 53); then make a B and B B$'$ (Fig. 54) equal respectively to B $1'$ and B B$'$ (Fig. 53). Make B C and B$'$ C$'$ (Fig. 54) equal to $b'\,c'$ and 1, 2 (Fig. 53); then make B$'$ C and C C$'$ (Fig. 54) equal respectively to C $2'$ and C C$'$ (Fig. 53). Make C D and C$'$ D$'$ (Fig. 54) equal to $c'\,d'$ and 2, 3 (Fig. 54), then make C$'$ D and D D$'$ (Fig. 54) respectively equal to D $3'$ and D D$'$ (Fig. 53). Make D E and D$'$ e (Fig. 54) equal to d' E and $3\,e$ (Fig. 53), then make D$'$ E and E e (Fig. 54) respectively equal to E $4'$ and E e (Fig. 53). Draw curves through the points thus obtained from E to E and e to e to complete the pattern. Patterns for the remaining segments of the ventilator may be marked out similarly.

Patterns for Ship's Ventilator having Longitudinal Seams.—Let N, A, E, F, L, and M (Fig. 55) represent a side elevation of the ventilator. Divide the arcs A E and L F equally as at B D and K G, then join B K and D G with straight lines. Now draw the dotted semicircles on the lines A L, B K, D G, E F; divide each of them equally into four parts, and from the points of division draw the dotted straight lines as indicated, in order to obtain the points shown in the elevation. Draw a curve through the points 1, 2, 3, and 4 to form the central line, then draw other curves through a, b, d, and e, and l, k, g, and f to form elevations of the seams. A pattern for the back is shown by Fig. 56, where A, B, C, D, and E are made equal to A, B, C, D, and E

in Fig. 55. Draw lines through B and D at right angles to the central line, and make B b and D d on each side of the



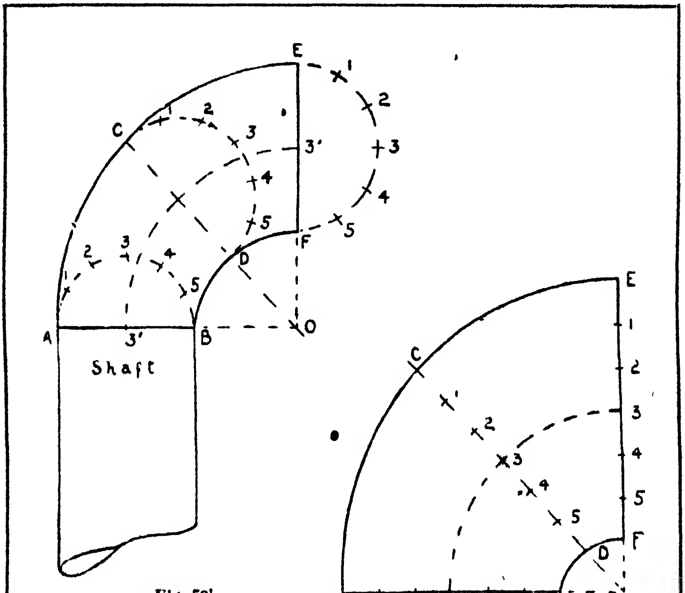
Figs. 55 to 58.—Patterns for Ship's Ventilator having Longitudinal Seams.

central line (Fig. 56) equal to B b' and D d' (Fig. 55). Make b a and d e (Fig. 56) equal to b a and d e (Fig. 55); make a a

(Fig. 56) equal to twice A a' (Fig. 55); similarly make $e\,e$ (Fig. 56) equal to twice E e' (Fig. 55). Curves are now drawn to pass through the points thus obtained to complete the pattern. A pattern for the sides is shown by Fig. 57. Draw O a and O e at right angles, reproduce in Fig. 57 the curve 1, 2, 3, and 4 (Fig. 55), and through the points 2 and 3 draw the radial lines to O. Make $a\,1\,l$ (Fig. 57) equal to $a'\,1'\,l'$ (Fig. 55); make $b\,2\,k$ (Fig. 57) equal to $b'\,2'\,k'$ (Fig. 55); make $d\,3\,g$ (Fig. 57) equal to $d'\,3'\,g'$ (Fig. 55), and make $e\,4\,f$ (Fig. 57) equal to $e'\,4'\,f'$ (Fig. 55). The pattern is completed by drawing curves to pass through the points thus obtained. A pattern for the throat is shown at Fig. 58, where L, K, H, G, and F are made equal to L, K, H, G, and F (Fig. 55). Draw lines through these points at right angles to the central line, then make G g and K k on each side of the central line in Fig. 58 equal to G g' and K k' (Fig. 55). Make $g\,f$ and $k\,l$ (Fig. 58) equal to $g\,f$ and $k\,l$ (Fig. 55). Make $l\,l$ (Fig. 58) equal to twice L l' (Fig. 55), and make $f\,f$ (Fig. 58) equal to twice F f' (Fig. 55). Draw the necessary curves through the points thus obtained to complete the pattern. The bell-mouth N A M L (Fig. 55) may be worked up from an ordinary cone pattern, which is readily obtained in the usual way. It should be understood that absolutely perfect patterns cannot be drafted for bodies having a compound curved surface, therefore a little paring away of metal which has been subjected to repeated hollowing and stretching is unavoidable. A good plan is to note particularly how a pattern works up, and then to make any small modification that experience proves to be necessary; but it is always advisable to have the pattern sufficiently "full" to begin with.

Pattern for Tapering Ventilator made in Two Halves with Throat and Back Seams:—Let A B C D E F (Fig. 59) represent a side elevation of the ventilator for which a pattern

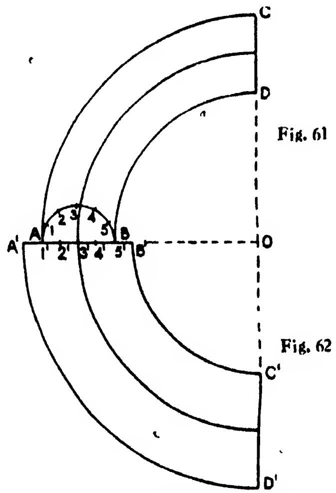
is required, the seams being indicated by ACE and BDF. First describe semicircles on the lines AB, CD, and EF, then divide them equally as at 1, 2, 3, 4, and 5. With O (Fig. 60) as centre, and radius equal to O3′ (Fig. 59), describe the dotted quadrant 333 (Fig. 60). The lines EO and AO (Fig.



Figs. 59 and 60.—Pattern for Ventilator.

60) are drawn square to each other, and the line CO (Fig. 60), of course, bisects the dotted arc, as illustrated. From 3, on the line AB (Fig. 60) set off on each side three divisions, making them equal to the divisions of the semi-

circle on the line AB (Fig. 59). Thus the line AB (Fig. 60) will be equal in length to that of the dotted semicircle on the line AB (Fig. 59). Similarly from 3 on the line CD (Fig. 60) step off the six divisions, making them equal to the six divisions contained in the semicircle on the line CD



Figs. 61 and 62.—Pattern for Bend having Two Seams.

(Fig. 59). Then from 3 on the line EF (Fig. 60) step off six divisions, making them equal to those contained in the semicircle on the line EF (Fig. 59). Curves are then drawn through ACE and BDF to complete the pattern. As the letter references in both figures are coincident, no difficulty should be experienced in following the method of working. In the illustration the shaft is drawn parallel, the taper being confined to the head of the ventilator, and this is preferable from every point of view.

Pattern for Bend made in Two Halves with Throat and Back Seams.—Let ABCD (Fig. 61) represent an elevation

of the bend. First describe a semicircle on A B and divide it equally as at 1, 2, 3, 4, and 5. Produce A B and C D to meet at O. To draw the pattern (Fig. 62) set the compasses to one of the divisions of the semicircle, say 4 5, then starting from 3′, step off three divisions on each side, so as to obtain A′, 1′, 2′, 3′, 4′, 5′, and B′ (Fig. 62). With O as centre, describe

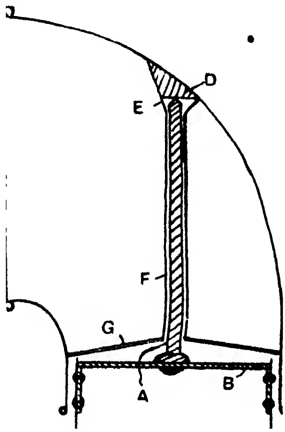


Fig. 63.—Section of Revolving Cowl.

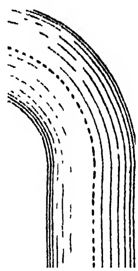


Fig. 64

Figs. 64 to 66.—Bending Brass and Copper Pipes.

Fig. 65

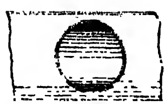


Fig. 66

arcs from A′ and B′, draw O D′ at right angles with O A′ to give A′, B′, C′, and D′ the pattern required for each half.

Details of Revolving Cowl.—Fig. 63 represents a sectional view of a revolving cowl of the lobster-back type; but the spindle mechanism is equally applicable to any other

type. The spindle A, which should have a hardened steel tip, is mounted on the cross-stay B, and this in turn is riveted to the pipe C, the latter, of course, being made to fit the smoke shaft. The bearing D may be made by enclosing a piece of very thick plate-glass in the oblique cone E, which, being soldered to the cowl, holds it in position. The shape of the glass bearing, as indicated, need not be slavishly adhered to—some use the inverted bottom of a strong wine-bottle—but care should be exercised so to fix the glass that no weak spot exists between the top of the spindle and underneath the cowl. F is a simple guide-tube, one end of which is attached to the oblique cone, the other being held in position by means of the cross-stays G, which in turn are secured to the cowl, as illustrated. The glass bearing is quite suitable for the weight mentioned, and in this connection glass has many advantages. No oil cup is shown in the illustration, since for this arrangement with a glass bearing none is required. If preferred, the spindle can be inverted and fixed to the cowl, in which case the glass bearing and guide tube would be mounted on the pipe cross-stays.

Bending Brass and Copper Pipes.—Brass and copper pipes of diameters ranging from $\frac{1}{8}$ in. to $\frac{1}{2}$ in. may be bent by hand without loading if care is exercised. If the pipe is hard, first anneal it; if it has a brazed seam the position of the latter is shown in Fig. 64; never bend the seam otherwise if it can be avoided. A good plan is to slightly flatten the seam of the pipe where it requires bending; then, placing the thumbs together, grip the pipe and gently bend it over the thumbs a little at a time by pulling the ends of the pipe towards you. Bring it to the required shape over one thumb only, meanwhile moving it to different points along the inner arc of the bend. The flattened

seam will now be found to have resumed its original shape, but it has prevented kinking. Pipes of larger diameters are loaded with pitch, resin, or lead before bending, and, in the absence of special tools such as steam power bending machines, etc., are bent with wooden mallets over mandrels or channelled blocks of the same shape as the required bend. The metal should be uniformly bent, and to this end the point of bending is constantly changed by moving the pipe to and fro. Kinks sometimes appear, especially in light tubes of large diameter, but these are gently hammered out with a half-round or convex hammer before melting out the pitch, resin, or lead. To make a **T or** branch joint, prepare the branch pipe as shown at Fig. 65, by chamfering the end with a smooth file, and by making it concave so that no obstruction of the other pipe may be caused. Now with a half-round smooth file make a hole in the other pipe (Fig. 66) until the chamfered end of the branch fits tight and true into it up to the shoulder. Both pipes are now tied with wire or otherwise secured for *brazing: this can be done on an open hearth*, or with a gas blowpipe over an iron basket of charcoal or coke, using suitable spelter with borax as a flux.

CHAPTER III

Conical Problems

Standard Cones Used in Sheet-metal Work and their Patterns.—Cones and parts of cones of various shapes and sizes play an important part in sheet-metal work. There are two kinds of cones—right cones and oblique cones; and for present purposes it will be sufficient to define a right cone as one whose apex is vertically over the centre of the base when the cone is placed on a horizontal plane. An oblique cone is one whose apex is not vertically over the centre of the base when the cone is placed on a horizontal plane.

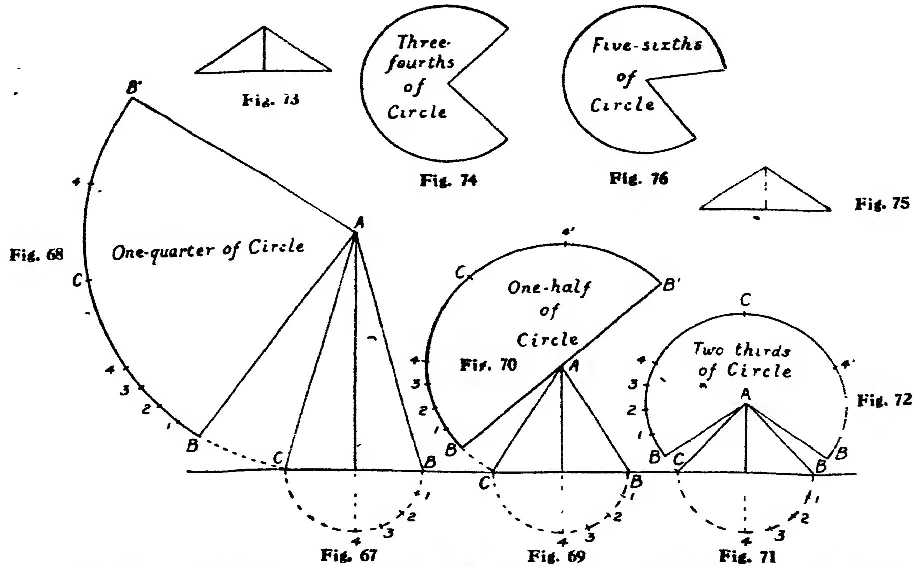
The standard cones are all right cones of definite shapes, with a fixed relationship of diameter to height; and their use is associated with repetition work where experience has sanctioned, if not dictated, the expediency of adhering to stereotyped conditions. Practical familiarity with the shapes of the standard cones and their patterns not only enables a workman readily to obtain a pattern for one of the given shapes, and thus facilitates speed of production, but it also enables him to utilise them for other purposes. For example, an approximate pattern for certain conical work may be required, and a knowledge of the standard shapes enables the worker to judge which will serve his purpose best. Some workers specialise to such perfection in this respect that they can obtain a surprising number of useful patterns, which although not strictly accurate, nevertheless serve their purpose from the practical point

of view when strict accuracy is subordinated to other considerations. One remarkable characteristic of these standard cones is that the pattern for each cone represents a certain definite segment of a circle, as will be demonstrated later.

Fig. 67 shows a cone which is known as the extinguisher shape, and is so called on account of the resemblance it bears to the old-fashioned candle extinguisher. It will be observed that its slant depth is equal to twice its diameter at the base, and its pattern is always a quarter of a circle whose radius is equal to the slant depth of the cone. This may be verified by developing the cone geometrically, as follows: First describe the dotted semicircle on the base of the cone (Fig. 67), and divide half of it equally as at 1, 2, 3 and 4. With A as centre and A C as radius, describe the arc (Fig. 68). Then with the compasses set to B 1 (Fig. 67) (one of the divisions of the semicircle), step off from B (Fig. 68) the divisions 1, 2, 3 and 4. The compasses should now be opened out to B 4 (Fig. 68), then with 4 as centre obtain C; with the latter point as centre obtain 4′, and similarly obtain B′. Unite B and B′ to A to give the pattern (Fig. 68), which will be found to be one-quarter of a circle.

Fig. 69 represents the well-known standard cone termed the funnel-shape, and it is so named because of its use in the making of funnels, although it is also used for other purposes. The characteristics of this cone are that its slant depth is equal to its diameter at the base, and its pattern is always a semicircle. This may be verified geometrically as in the former instance, by adopting the same method of procedure. A pattern for this cone is shown by Fig. 70.

The familiar standard cone known as the bottle top



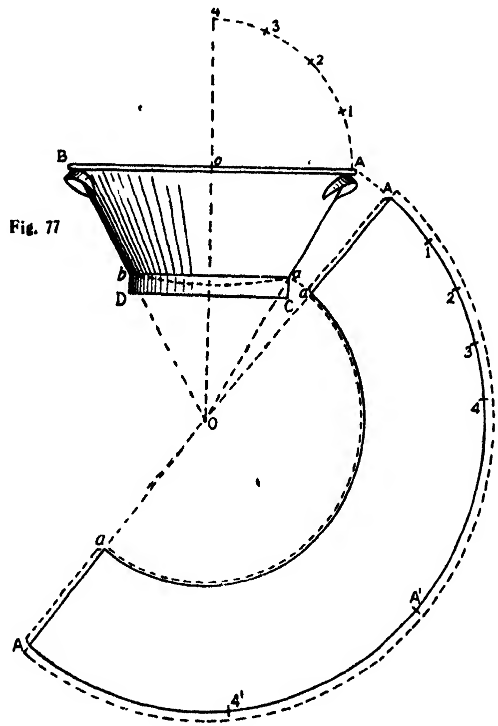
Standard Cones Used in Sheet-metal Work and their Patterns. Figs. 67 and 68.—Cone of Extinguisher Shape. Figs. 69 and 70.—Funnel-shape Cone. Figs. 71 and 72.—Bottle-top Cone. Figs. 73 to 76.—Watering-can Rose Cones.

is shown by Fig. 71. This shape is used for the tops of oil-bottles, for stove-pipe cowls, and for tapers resembling a milk-churn top. The slant depth of this cone is three-fourths of its diameter at the base, and the pattern is always two-thirds of a circle whose radius equals the slant depth of the cone. The pattern is shown by Fig. 72, and it may be verified in the same manner as in the preceding cases.

The standard cone represented by Fig. 73 is less frequently used than the others, and is known as the watering-can rose. It is interesting to note that the diameter of the base of this cone is one-and-a-half times its slant depth, and the pattern is always three-quarters of a circle whose radius equals the slant depth of the cone. The pattern is shown by Fig. 74. A slightly flatter cone than this is represented by Fig. 75, and the ratio of the slant depth to the base is as 3 to 5. A pattern for this cone is always five-sixths of a circle whose radius is equal to the slant depth of the cone, and it is shown by Fig. 76.

It should be distinctly borne in mind that allowances for any working edges that may be required should be added to the patterns; and it should be thoroughly understood that these cones may be utilised for purposes other than those implied by the distinctive terms given to them. Occasionally only part of the cone is required—the frustum as it is termed—but even so, certain standard shapes are generally used for certain standard work. The bottle-top shape, for example, may be advantageously employed for canister tops, milk-churn tops, conical strainers, cowls, milk sieves, as well as for bottles; and in like manner a different standard shape will suit other work better. The advantages of utilising the standard shapes to the

fullest possible extent are obvious, and will well repay the slight study involved in mastering the underlying principles.



Figs. 77 and 78.—Patterns for Domestic Wash Bowl.

Patterns for a Domestic Wash-bowl.—The domestic wash-bowl shown by Fig. 77 is a very handy utensil, which may be made either of tinplate or sheet zinc. The following dimensions will be suitable: Diameter of top

14 in., diameter of bottom 8 in., slant depth 6 in., depth of hoop 1 in.

To obtain Fig. 78, which is a pattern for the body, first describe the dotted quadrant A 4 (Fig. 77), using *o* as centre, and divide it equally as at 1, 2 and 3. Now produce A *a* and B *b* (Fig. 77) to obtain the centre O. Then with O as centre, draw the outer arc of the pattern from A (Fig. 77) and the inner arc from *a* (Fig. 77). Make A 1 2 3 4 (Fig. 78) equal to A 1 2 3 4 (Fig. 77); stretch the compasses from A to 4 (Fig. 78), then beginning at 4 (Fig. 78) step off the three distances A′, 4′ and A (Fig. 78). Unite A A to O to give A *a* and A *a*, the pattern required.

The outer dotted arc represents a wiring edge for the top, the inner dotted arc represents a working edge for the bottom, while the two dotted lines at the end of the pattern represent allowances for a grooved seam.

Pattern for Slightly Tapering Conical Body.—Let *a j* A J (Fig. 79) represent an elevation, and A *a′* E *e* J *j′* a half-plan of the tapering body for which a pattern is required. First divide the half-plan equally, as at B *b*, C *c*, D *d*, E *e*, F *f*, G *g*, and H *h*; then draw the dotted diagonal *a′* B, and with *a′* as centre and *a′* B as radius, draw the dotted arc to obtain B′, from which point draw the dotted line to *a*. All this is shown fully in Fig. 79 in order to make the method of working abundantly clear; and these preliminaries are necessary so as to obtain certain exact lengths and distances which need to be transferred from the elevation and plan to the pattern. In workshop practice, however, there is no need to draw all the lines, either in Fig. 79 or Fig. 80, these being inserted here merely for the sake of a lucid explanation. It will be sufficient for all practical purposes, when dealing with an equal tapering body, such as is now under considera-

tion, to take only one plan division (which gives the lengths A B and $a' b$), the true slant length a A, and the true diagonal length a B′ (Fig. 79). The entire pattern can be set out from these essential details, as follows: Make A a (Fig.

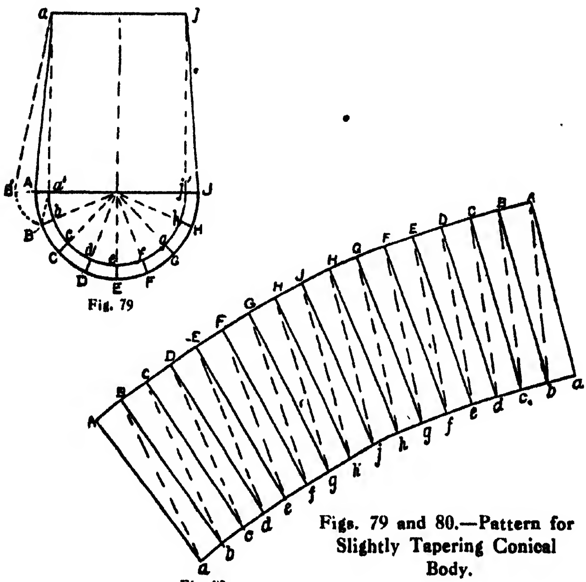


Fig. 79

Fig. 80

Figs. 79 and 80.—Pattern for Slightly Tapering Conical Body.

80) equal to A a (Fig. 79); make A B and $a b$ (Fig. 80) equal respectively to A B and $a' b$ (Fig. 79). With a (Fig. 80) as centre, and radius equal to a B′ (Fig. 79), obtain B (Fig. 80); then with the latter point as centre, and radius equal to A a (Fig. 79), obtain the point b (Fig. 80). Repeat this method of working until all the remaining divisions of the

pattern have been obtained in precisely the same manner. It will be seen that there are eight divisions in the half-plan, therefore the complete pattern must contain sixteen. The lettering on the pattern is coincident with that on the half-plan; but as the body is an equal-tapering body, all the divisions are alike in every respect, consequently, having obtained a pattern (A B *a b*, Fig. 80) for one of the plan divisions (A B *a' b*, Fig. 79), the remainder of the pattern is simply repetition work. The method of working here outlined will answer for equal tapering bodies of all dimensions, always provided that they are portions of right cones, such as this one is. For very large work, greater exactitude may be obtained by dividing the half-plan into a greater number of divisions; but for small work an even less number than shown in Fig. 79 will suffice. But the pattern, of course, will always contain twice that number of divisions which are contained in the half-plan.

Development of Cone Cut Obliquely.—Let K H G A (Fig. 81) represent an elevation of the cone, and *g a* an elevation of the oblique cut. First produce A H and G K to obtain O the apex of the cone. On the line A G describe the dotted semicircle, divide it equally as at 1, 2, 3, 4 and 5, and from these latter points, draw the dotted vertical lines at right angles to the line A G, in order to obtain B, C, D, E, and F. Then unite the points thus obtained to the apex O by drawing a series of converging dotted lines, as indicated. From those points where the converging dotted lines intersect the oblique cut, draw a series of lines parallel with the base of the cone, in order to obtain *b'*, *c'*, *d'*, *e'*, *f'*, and *g'* on the side of the cone. Now with O as centre, draw a series of arcs from H, *a*, *b'*, *c'*, *d'*, *e'*, *f'*, *g'*, and A (Fig. 81), and make the distances A, B, C, D, E, F, and G (Fig. 82)

equal to A, 1, 2, 3, 4, 5, and G on the dotted semicircle (Fig. 81). From the points of division on the outer arc of Fig. 82 draw a series of dotted lines converging at O. A curve is then drawn from *a* to *a* passing from one arc to another in the space of one division, as illustrated by

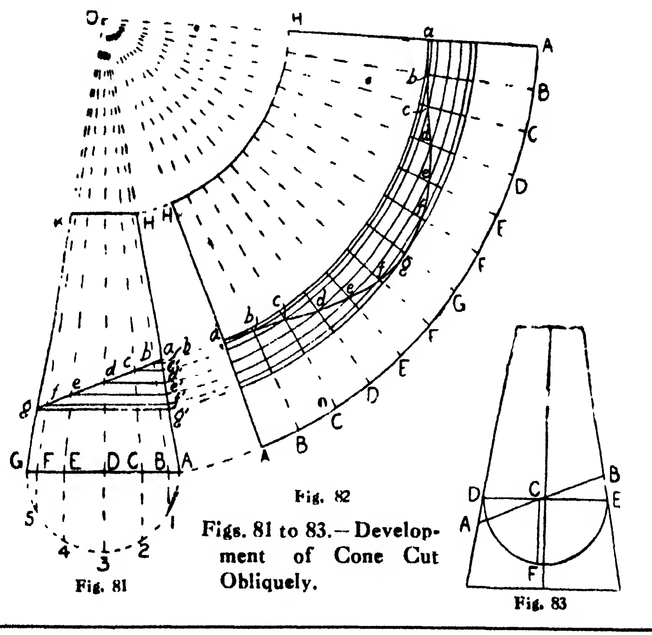


Fig. 81

Fig. 82

Fig. 83

Figs. 81 to 83.—Development of Cone Cut Obliquely.

a b c d e f g (Fig. 82). This curve in Fig. 82 represents the oblique cut *g a* (Fig. 81). The development of that part of the cone above the oblique cut (Fig. 81) is represented by H H *a b c d e f g* (Fig. 82). The development of that part of the cone below the oblique cut (Fig. 81) is represented by A A *a b c d e f g* (Fig. 82). The section of an obliquely cut cone is an ellipse. Referring to Fig. 83, A B would

be the major axis and CF one-half the minor axis. The length of the major axis is obvious, being simply the length of the oblique cut. To obtain the length of the minor axis bisect AB (Fig. 83) in C. Draw DE through C and parallel with the base of the cone. Describe the semi-

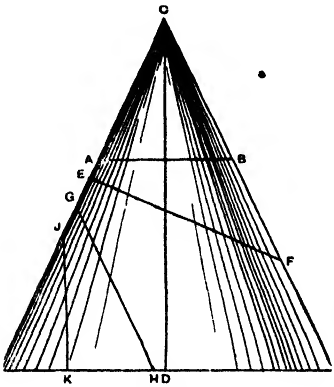


Fig. 84

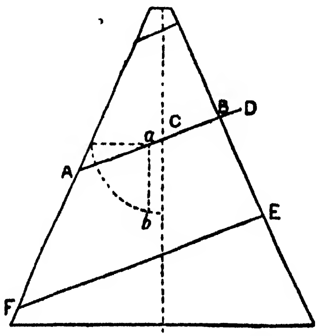


Fig. 85

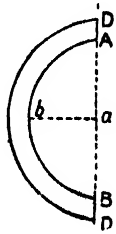


Fig. 86

Fig. 84.—Conic Sections.

Figs. 85 and 86.—Pattern for Sheet-metal Screw on Cone.

circle DFE, then draw CF parallel with the central line of the cone. Twice CF gives the required length of the minor axis.

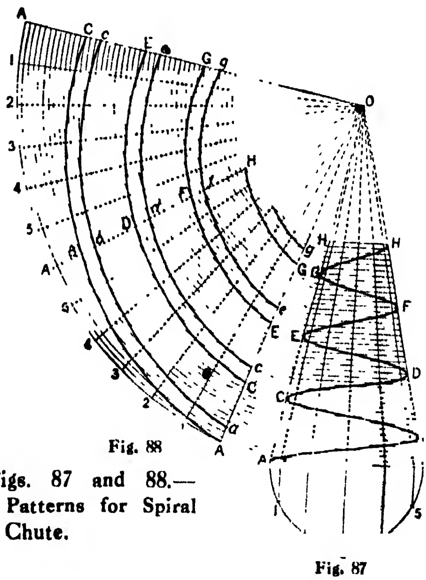
Conic Sections.—Fig. 84 shows diagrammatically a number of conic sections. A section taken across the line AB, parallel to the base, forms a complete circle; a section of plane CD, the line of axis, forms a triangle; a section

taken across the line EF, at an angle to the base, forms an ellipse; a section across the line GH, parallel to the slope of the cone, forms a parabola; and a section on JK, cutting the side at an angle less than a parabola, forms a hyperbola.

Pattern for Sheet-metal Screw on Cone.—It is extremely difficult, if not impossible, to set out accurately a pattern of this description owing to the fact that a screw is essentially a twisted surface, and as such, cannot be developed like a plain surface. A good approximate pattern, however, may be set out as follows, which, with judicious stretching, will be found to answer all practical requirements. Let Fig. 85 represent an elevation of the cone showing the pitch of the screw. On referring to the illustration, it will be seen that the screw may be regarded as a series of semi-ellipses of different dimensions, therefore a pattern for each will be required. Taking the line AB as an example, a section of the cone on this line would be an ellipse whose major axis is AB. To obtain the length of the minor axis, bisect AB in *a*, describe a quarter circle, as indicated, from the centre C, and draw a line parallel with the central line of the cone from *a* to *b*, which is half the length of the minor axis required. But as the screw will encircle only one-half of this section, only a semi-ellipse will be required, which is shown in Fig. 86, where AB equals AB (Fig. 85), *a b* equals *a b* (Fig. 85), and DA and DB (Fig. 86) represents the width of the screw as shown at BD (Fig. 85). A continuation of this screw pattern will be a semi-ellipse whose major axis is AE, while a further continuation will be a semi-ellipse whose major axis is EF. These semi-ellipses should be cut out and fastened together either by soldering or riveting. A little hammering will be necessary in order to stretch the metal to obtain the required twist.

Conical Problems

Patterns for Spiral Chute.—The chute is intended to travel round the frustum of a cone, therefore let A A H H (Fig. 87) represent a cone frustum of the same dimensions as the spiral chute. Produce A H, A H to obtain O; describe a semicircle on A A, which divide equally as at 1, 2, 3, 4, and 5, and from these latter points draw lines to the base



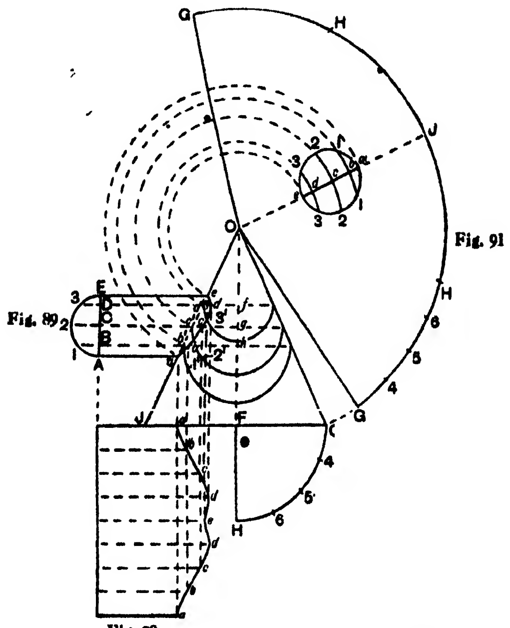
Figs. 87 and 88.—Patterns for Spiral Chute.

line and at right angles with it, and then draw radial lines to O, as illustrated. Mark the pitch of the chute as at B, C, D, E, F, and G; then in order to obtain the true elevation of the spiral, divide A B, on the right side of the cone (Fig. 87), into the same number of parts as are contained in the semicircle on the base of the cone, namely, six. From these points draw lines parallel with A A, and

then draw a curve from A to B passing from one parallel line to another in the space between two radial lines. Continue this method of working until the complete spiral is obtained. Patterns for the side plates (or the rim of the chute) may be set out as in Fig. 88. With O as centre, draw a series of arcs from where the parallel lines touch the side of the cone, and along the outer arc step off twice the number of distances that are contained in the cone base semicircle, as indicated. From these points of division draw radial lines to O. A line now drawn from A through B to C (Fig. 88), passing from one arc to another in the space between two radial lines, gives the shape of the rim base represented in elevation by ABC (Fig. 87). The depth of the rim is indicated by the arc *a b c* (Fig. 88), and, of course, this may be set off to any desired measurement. Similarly, the arcs CDE, *c d e*, and EFG, *e f g* (Fig. 88) are the exact shapes and lengths required to form those revolutions of the spiral which are shown in elevation at CDE and EFG (Fig. 87), while the arc GH (Fig. 88) is the shape and length required to form GH (Fig. 87).

Development of Cylinder Intersecting Cone.—Let Fig. 89 represent an elevation of the cylinder and cone. On the line EA, at the end of the cylinder, describe a semicircle. Divide it into equal parts as at 1, 2, 3, and from these points draw lines parallel with the sides of the cylinder to cut the cone in the points b', c' and d', and produce them until they reach the other side of the cone. To find the junction line, first describe from the centres *f*, *g*, and *h*, the three semicircles which are in reality half-plans of the cone on the lines $d' f$, $c' g$, and $b' h$, produced. Now make $1' b$ equal to 1 B, $2' c$ equal to 2 C, and $3' d$ equal to 3 D, and draw through the points thus obtained

the required junction line. To draw the pattern for the cylinder, set the compasses to one of the divisions of the semicircle as at A 1 (Fig. 89), and along a straight line from A to A (Fig. 90) step off twice the number of distances



Figs. 89 to 91.—Development of Cylinder Intersecting Cone.

that are contained in the semicircle (Fig. 89). Dotted lines are now projected from *a*, *b*, *c*, *d*, and *e* on the junction line (Fig. 89), to give the points *a*, *b*, *c*, *d*, and *e* (Fig. 90), and a curve is drawn through these latter points to give the pattern required. To obtain a pattern for the cone,

describe the quadrant F G H (Fig. 89), and divide it equally as at 4, 5, and 6. Then with O as centre and O G as radius, describe an arc (Fig. 91). With compasses set to one of the divisions of the quadrant as at G 4 (Fig. 89) step off from G to H (Fig. 91) the four distances indicated; open the compasses to G H, obtain the points J, H, and G, and join G O to complete the pattern. The hole in the cone can now be marked. With O as centre, and O *a*, O *b′*, O *c′*, O *d′*, and O *e* (Fig. 89) as radii respectively, describe the dotted arcs to just beyond the centre line of the pattern (Fig. 91). Make *b* 1 on each side of the centre line (Fig. 91) equal to the arc *b′* 1′ (Fig. 89); similarly make *c* 2 and *d* 3 (Fig. 91) equal respectively to *c′* 2′ and *d′* 3′ (Fig. 89). A curve drawn through the points thus obtained on the pattern gives the shape of the hole.

Pattern for Cone Intersected by Inclined Cylinder.—First draw an elevation of the cylinder penetrating the cone as in Fig. 92, and let Fig. 93 represent a half-plan, where it will be seen that the cylinder enters the cone out of the centre. On one end of the cylinder describe a semicircle, which divide into four equal parts, and through the points of division draw lines parallel to the sides of the cylinder, as at *a a′*, *b b′*, etc. (Fig. 92). Bisect *b b′*, *c c′*, and *d d′* in F′, G′, and H′, then with F′ as centre, and F′ *b* as radius, describe a small arc. Similarly with G′ and H′ as centres, and G′ *c* and H′ *d* respectively as radii, describe other arcs on each side of the central line. Theoretically these arcs should be elliptical; but in order to avoid confusion, they are here treated as being circular, which in the present example may be considered practically correct. Set off F′ 1′, G′ 2′, and H′ 3′ (Fig. 92) equal to F 1, G 2, and H 3, and through these points draw lines parallel to the sides of the pipe to cut the arcs previously

drawn, in the points *j*, *k*, and *l*. Then from these latter points draw the dotted vertical lines to cut the parallel lines of the cylinder in the points *f*, *g*, and *h*, through

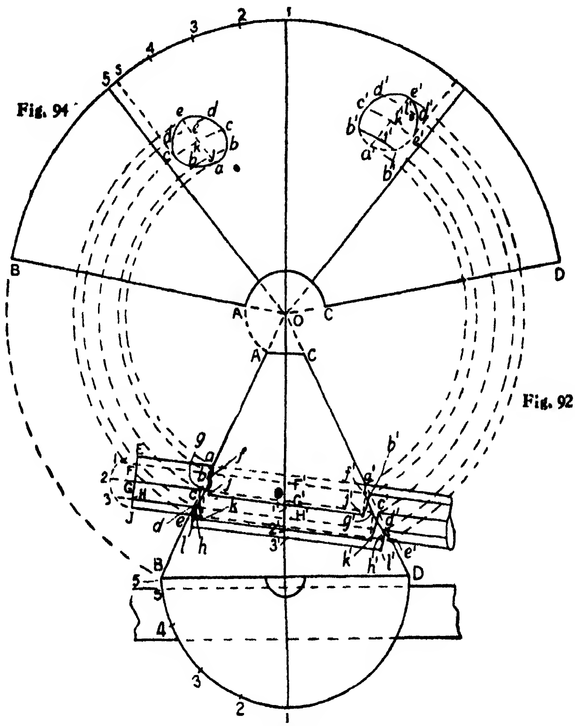
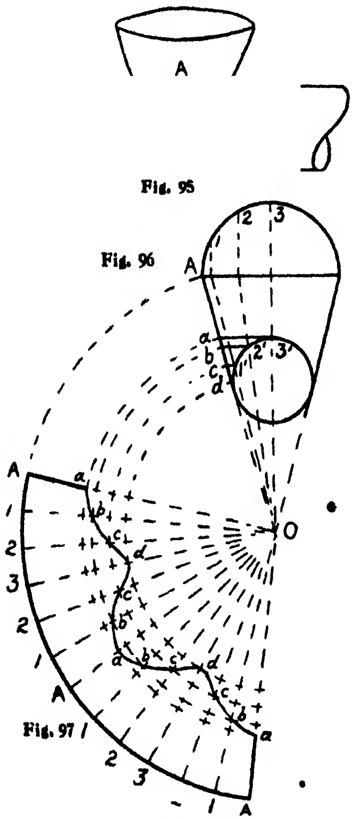


Fig. 93

Figs. 92 to 94.—Pattern for Cone Intersected by Inclined Cylinder.

which the intersection curve is drawn. To draw the pattern for the cone (Fig. 94), with O as centre, and O A and O B (Fig. 92) as radii, describe the arcs as indicated. Set off the distances 1, 2, 3, 4, 5 (Fig. 94) equal to those

marked 1, 2, 3, 4, 5 (Fig. 93). Then with the compasses set to 1 5, mark off the three remaining quarters of the pattern to give A, B, C, and D, the pattern complete. The shape of the holes is obtained by drawing the dotted arcs from *a*, *b*, *c*, *d* and *e* on the one side, and from those marked similarly on the other side of Fig. 92. Set off 5 s (Fig. 94) equal to 5 s (Fig. 93), and from s (Fig. 94) draw the dotted line parallel to 5 o. Make *l d*, on each side of the central line in Fig. 94, equal to the length of the arc *l d* (Fig. 92); similarly make *k c* and *j b* (Fig. 94) equal to *k c* and *j b* (Fig. 92). A curve drawn to pass through the points thus obtained gives the required shape.



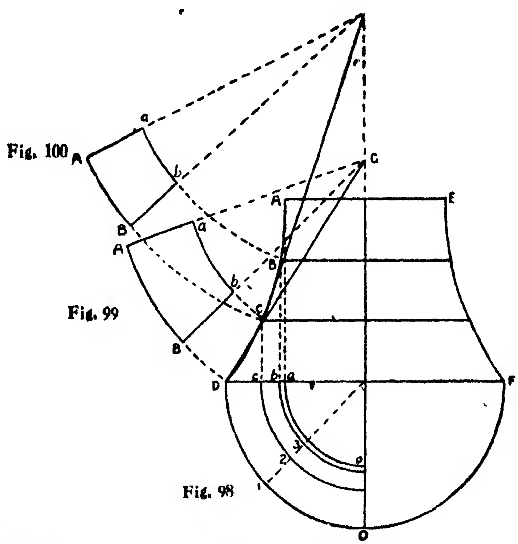
Figs. 95 to 97.—Pattern for Tapering Centre Tee-piece.

Pattern for Tapering Centre Tee-piece.—Let Fig. 95 represent the tee-piece, and A the tapering centre for which a pattern is required. First draw an end elevation (Fig. 96), and on the top line draw a semicircle, which divide equally as at A, 1, 2, and 3.

From these latter points draw the dotted lines at right angles to the top line, until they intersect it, and thence to the apex of the cone. The apex O (Fig. 96) is obtained by producing the sides of the taper. This method of procedure gives the points 1′, 2′ and 3′ on the junction line, as illustrated. Lines are now drawn from these latter points, and parallel with the top line, so as to give *a*, *b*, and *c* on the side of the cone. To draw the pattern (Fig. 97), with O as centre, describe a series of arcs from A, *a*, *b*, *c*, and *d* (Fig. 96), and make A, 1, 2 and 3 round the outer arc (Fig. 97) equal to A, 1, 2, and 3 on the semicircle (Fig. 96). Since A, 1, 2 and 3 (Fig. 96) represents one-quarter of the circumference, these distances must be set off four times round the outer arc of Fig. 97, in order to obtain the whole circumference. A series of dotted radial lines are now drawn from the points on the outer arc (Fig. 97) converging at O. An unbroken line is then drawn from *a* to *b*, *c*, *d*, and so on, passing from arc to arc in the space of one division as indicated, to complete the pattern. For practical purposes it is really only necessary to plot out one-quarter of the pattern (the A *a d* 3 part) since the complete pattern can be built up from this segment.

Patterns for Bell-bottomed Stack.—Assuming that it is a bell-mouthed circular stack, let ADEF (Fig. 98) represent an elevation, and D*a*O*o* a quarter-plan. Divide the elevation to give the number of tiers, as indicated, and from the points of division draw perpendiculars down to the ground line, from which describe the quarter circles, as shown in the quarter-plan. The number of plates required for each tier must now be decided, and the quarter-plan accordingly divided. Eight are here assumed, hence the quarter-plan is divided equally by the

dotted radial line. On reflection it will be seen that each tier may be regarded, for all practical purposes, as consisting of part of a cone, the final bell shape, of course, being obtained by judicious hammering and stretching of the plates round each diameter. Therefore to obtain a pattern for the plates of the bottom tier, first draw the

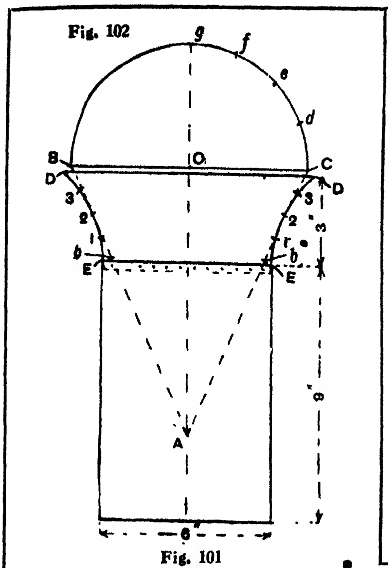


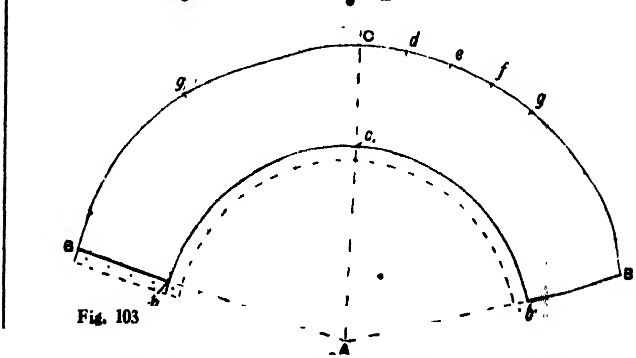
Figs. 98 to 100.—Patterns for Bell-bottomed Stack.

straight line D G (Fig. 98), resting on the curve D C; then with G as centre, and G D and G C respectively as radii, describe the arcs as indicated. Make A B (Fig. 99) equal to D 1 (Fig. 98), and join A and B to G, in order to obtain A *a* B *b*, the pattern required. Laps for seams are added to the pattern, then eight plates cut to this shape will constitute the bottom tier. A pattern for the eight plates

of the second tier is shown by Fig. 100, which is obtained somewhat similarly; but it should be noted that the radii and centres are not identical in both cases, while the length of the arc AB (Fig. 100) should equal $c\,2$ (Fig. 98). A pattern for the other tier is not shown, but it can be readily obtained by adopting the same method of procedure, which should be repeated for as many tiers as may be desired.

Pattern for Bell-mouthed Pipe.—It is better and easier to make the pipe in two pieces—one





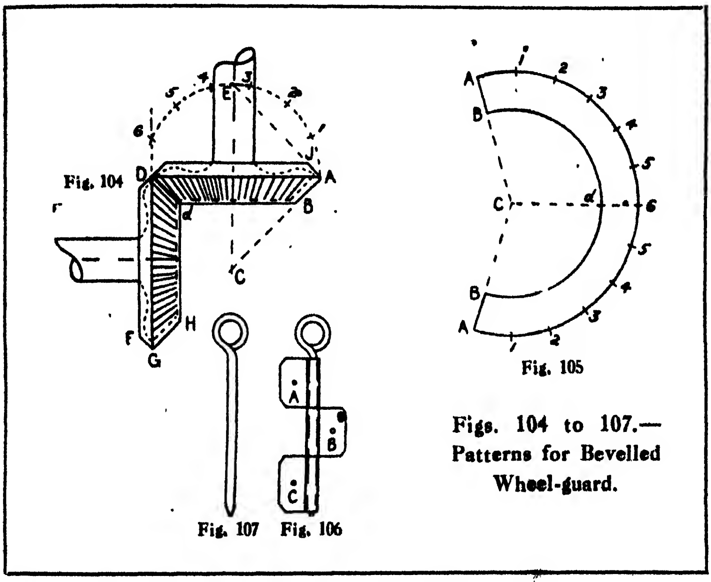
Figs. 101 to 103.—Pattern for Bell-mouthed Pipe.

piece, the straight pipe, which needs no pattern, and the bell-mouthed tapering part, for which a pattern is herewith

described. First draw an elevation (Fig. 101) and divide the curve DE into four equal parts as at 1, 2, 3. Now draw lines AB and AC to touch the inner centres of the curves at the points 2, and from these points set off on each side along the lines AB and AC, the division distances of the curves DE, as at B*b*, C*b*. These lengths will represent the true distances of the curves DE when drawing the pattern. With ρ (Fig. 102) as centre, and OC as radius, draw a half plan of the cone ABC, and divide the arc C*g* into four equal parts. To draw the pattern (Fig. 103), with A as centre, and radius equal to AC (Fig. 101), describe an arc, and from the same centre with A*b* (Fig. 101), as radius, draw another arc. From C (Fig. 103) set off on each side the distances C to *g* (Fig. 102), and make *g*B equal to *g*C. Draw lines from B to A, to give the pattern required. The dotted lines along one side, and inside the smaller arc, are allowances for riveted seams. The pattern is now turned to shape, and riveted along the seam, after which it is shaped with a stretching hammer. Begin with a circle of blows around each edge, and gradually work the metal outwards to the required shape. Use best iron, and if necessary anneal it once or twice, then rivet it to the straight pipe as shown in Fig. 101.

Patterns for Bevelled Wheel-guard.—Let Fig. 104 represent an elevation of the wheel-guard for which patterns are required. On the line DA describe the dotted semicircle, then produce the line GD to cut it in the point marked 6. Now divide the arc A6 equally, as at 12345. Produce AB to obtain the centre C, then with C (Fig. 105) as centre, and with radius equal to CB (Fig. 104), describe the arc BB (Fig. 105). With the same centre, and with radius equal to CA (Fig. 104) describe the arc AA (Fig. 105). To obtain the true length of the arc AA (Fig. 105) set the

compasses to one of the divisions—say A 1—of the dotted semicircle (Fig. 104), then starting at A (Fig. 105) step off twice as many divisions as are contained in the arc A 6 (Fig. 104), as illustrated. Now join A A to C (Fig. 105) to complete the pattern for that portion of the wheel-guard shown in elevation at D *d* A B (Fig. 104). As the wheel-



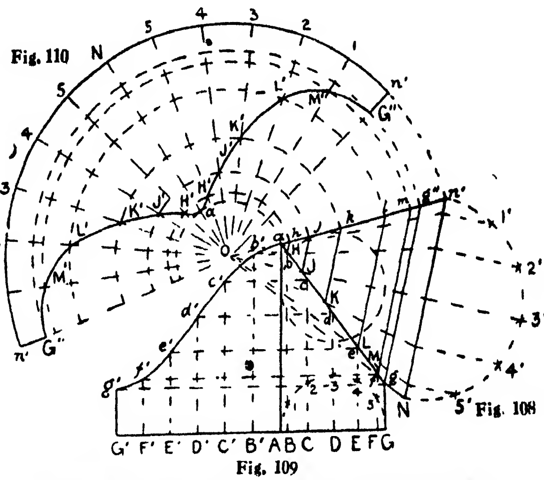
Figs. 104 to 107.—
Patterns for Bevelled
Wheel-guard.

guard, however, must necessarily be made in halves, join C 6 (Fig. 105), which thus cuts the pattern in halves, each half being marked A B *d* 6. The patterns for the upper portion of the wheel-guard may be set out similarly, but the centre in this case is obtained by producing A J to obtain E (Fig. 104). Whatever working edges may be required, such, for instance, as capping edges, must be added to the patterns. The wheel-guard is now made in halves, each half having a soldered joint at D *d* (Fig. 104). The joints at

D, JAB and FGH are detachable; and a suitable joint for this purpose is shown enlarged at Fig. 106. This joint consists of three strips of metal which are doubled over, and then sunk over, an iron pin on the crease iron. The pin is shown by Fig. 107, and when the joint is assembled it resembles a hinge. The parts A and C (Fig. 106) are soldered, and if necessary, riveted, to one half of the guard, while the other part B is similarly fixed to the other half of the guard. The guard can then be either assembled or dismantled by inserting or withdrawing the joint pins as required.

Patterns for Conical Head.—Let A *a n'* N *g* G (Fig. 108) represent an elevation of the conical head attached to a cylindrical pipe for which patterns are required. When making the elevation care should be exercised in the placing of the mitre line, or junction line, and the best way of doing this is to describe the dotted circle, equal in diameter to that of the pipe; then draw the cone with one side resting on it, as indicated. By thus drawing one side of the cone and one side of the pipe tangential to the circle, the correct junction line is ensured. Describe the dotted semicircle on the base of the pipe A G (Fig. 108), divide it equally as at 1, 2, 3, 4, and 5, and through these points draw the vertical lines in order to obtain *b*, *c*, *d*, *e*, and *f* on the junction line. A pattern for the pipe can now be drawn as follows: Make A, B′, C′, D′, E′, F′, and G′ (Fig. 109) equal to A, 1, 2, 3, 4, 5, and G (Fig. 108), and erect the dotted perpendiculars, as illustrated. A series of dotted horizontal lines is now drawn from *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 108) to cut the dotted perpendiculars in the points *b′*, *c′* *d′*, *e′*, *f′*, and *g′* (Fig. 109). A curve drawn from *a* to *g′* through the points thus obtained, and a straight line from *g′* to G′, completes one-half of the pattern for the pipe. The other half is, of

course, identical, and can be obtained similarly. Before the conical pattern can be drawn, certain points must be fixed on the junction line as follows: First produce $n'a$ and N g (Fig. 108) in order to obtain O, the apex of the cone. On the base of the cone N n' describe a semicircle, divide it equally, and from the points of division draw a series of



Figs. 108 to 110.—Patterns for Conical Head.

dotted lines to, and at right angles with, the base line, and from thence to O, as illustrated. From where these dotted lines intersect the junction line at H, J, K, L, and M, draw lines parallel with the base of the cone in order to obtain h, j, k, l, and m. Draw also a parallel line from g to give g''. A pattern (Fig. 110) for the conical head can now be drawn. With O as centre, draw a series of arcs from a, h, j, k, l, m, g'' and n' (Fig. 108). Now make n', 1, 2, 3, 4, 5

and N (Fig. 110) equal to n', $1'$, $2'$, $3'$, $4'$, $5'$, and N (Fig. 108), and from these points on the outer arc of Fig. 110 draw a series of dotted lines converging at O. A curve, G'', M', L', K', J', H', *a* is then drawn passing from one arc to another in the space of one division, as indicated, to complete the pattern. Working edges for seams, etc., must be added to the patterns as and where required.

CHAPTER IV

Oblique Conical Problems

Pattern for Cone with Straight Side.—First draw an elevation of the cone as at *a g* A G (Fig. 111), and produce the

Fig. 112

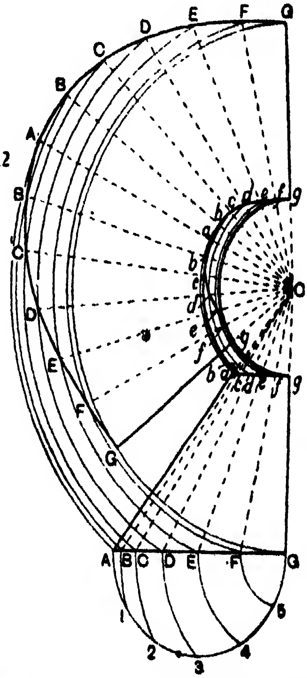


Fig. 111

Figs. 111 and 112.—Pattern for Cone with Straight Side.

sides A *a* and G *g* in order to obtain O. On the line A G describe a semicircle, and divide it into six equal parts; then, using G as centre, draw with the compasses the arcs from

the points of division to the base of the cone, in order to obtain B, C, D, E, and F, and join these with dotted lines to O as indicated. This is preliminary to drawing the pattern, as certain necessary working points must first be obtained. Now, with O as centre, draw arcs from A, B, C, D, E, F, and G and *a*, *b*, *c*, *d*, *e*, *f*, and *g*. Then with compasses set to one of the divisions of the semicircle, say A 1, step off from G (Fig. 112) six distances (passing from one arc to another in the space of one distance), until the outer arc is reached in the point A. From this point another six distances are stepped off similarly, but from the outer to the inner arc, and from A, B, C, D, E, F, and G, the points thus obtained, draw the dotted lines to O. A curve is now drawn through the points of division from G to G (Fig. 112), and a similar curve is also drawn from *g* to *g*, thus giving G *g* G *g*, the pattern required. It will be noted that the seam will be down the straight side in this instance; but, if desired, it can be set out to coincide with any of the dotted lines F *f*, E *e*, D *d*, C *c*, B *b*, or A *a*, in the elevation, by simply starting to mark the pattern from that arc which originates in the particular line selected.

Pattern for Oblique Cone Intersecting Cylinder.—Let O A E (Fig. 113) represent an elevation of the cone, F H K A′ an elevation of the cylinder, and the semicircle K N A′ a half-plan of the cylinder. Produce O A to obtain the point *a*, and from this point draw the dotted base of the cone. On this base draw the semicircle, which divide equally as at 1, 2, 3, and from these points draw dotted lines to the apex. From *b*, *c*, and *d* draw dotted lines as indicated, and make $b'1'$, $c'2'$, $d'3'$ equal to $b1$, $c2$, and $d3$. From 1′, 2′, and 3′ draw dotted lines to O′, and where they cut the half-plan of the cylinder erect vertical lines to meet the corresponding radial lines of the cone, thus obtaining the points

of intersection. For example, take the dotted line $c\,2$. This becomes $c'\,2'$, and when $2'$ is joined to O$'$, it cuts the half-plan of the cylinder in C$'$, consequently a vertical line is erected on this point, which in turn cuts the radial line O 2 in the point C, therefore C becomes a point of intersection. A little careful study will render the method of working

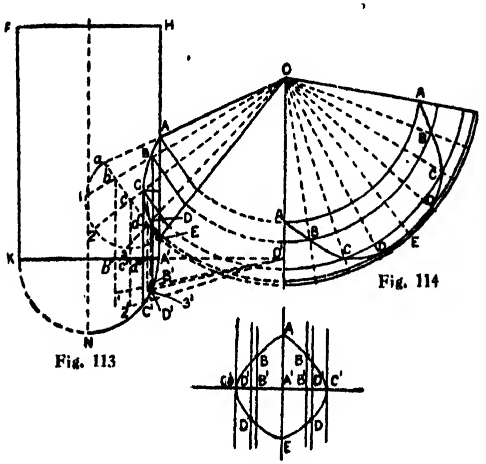


Fig. 113

Fig. 114

Fig. 115

Figs. 113 to 115.- Pattern for Oblique Cone Intersecting Cylinder.

quite clear. After obtaining the junction line by means of the intersection points, lines parallel with the base of the cone should be drawn from A, B, C, and D to the side of the cone, whence the pattern for the cone may be set out. The pattern (Fig. 114) is practically self-explanatory, and the outer arc contains twice the number of divisions that are contained in the semicircle on the base of the cone (Fig. 113). The shape of the hole to be cut in the cylinder is

shown in Fig. 115, where the distances A′, B′, C′ and D′ are equal to A′, B′, C′ and D′ on the half-plan of the cylinder (Fig. 113), while the vertical distances above and below the central line (Fig. 115) are equal to those above and below C in Fig. 113. A curve drawn through the points obtained gives the shape of the hole.

Cylinder Intersecting Cone at an Inclination.—Let ABCD in Fig. 116 represent an elevation of the cone, and k'KPp' the elevation of an inclined cylinder that penetrates the cone. The inter-penetration, or the junction curve, here shown in elevation at $k'123p'$ is required. First divide the quadrant HO′D into four equal parts, and join G, F, and E to O′. From G, F, and E draw the dotted vertical lines to give the points g, f, e on the ground line XY, and from the points thus obtained draw generating lines to O. On KP describe a semicircle, and equally divide it as at l, m, n, and from these points draw lines Ll', Mm', and Nn' parallel to Kk', and produce these lines so as to give respectively the points G′, F′, E′, f'2, and e on the generating lines. From G′ drop the dotted perpendicular to a on O′G, and repeat this method of working from F′ to b on O′F, from E′ to c on O′E, and from l' to d on the ground line XY. Similarly from f' to b' on O′F, from a point that is practically coincident with 2 (and which may therefore be allowed to stand for it) to c' on O′E, from m' to d' on the ground line, from e to c'' on O′E, and from n' to d'' on the ground line. Now draw the curves $a\,b\,c\,d$, $b'\,c'\,d'$, and $c''\,d''$. From LMN on the end of the cylinder draw the dotted lines to the ground line, so as to give the points L′, M′, N′, and produce them, making L′l'' equal to Ll, M′m'' equal to Mm, and N′n'' equal to Nn. From l'' draw a line parallel to XY, cutting the arc $a\,b\,c\,d$ in the point 1′, which is the plan of a point in the curve of penetration of the cylinder and cone.

From this point draw a vertical line cutting the line Ll' produced in 1, thus representing this point in elevation. Similarly from m'', with a parallel line to the curve $b'c'd'$,

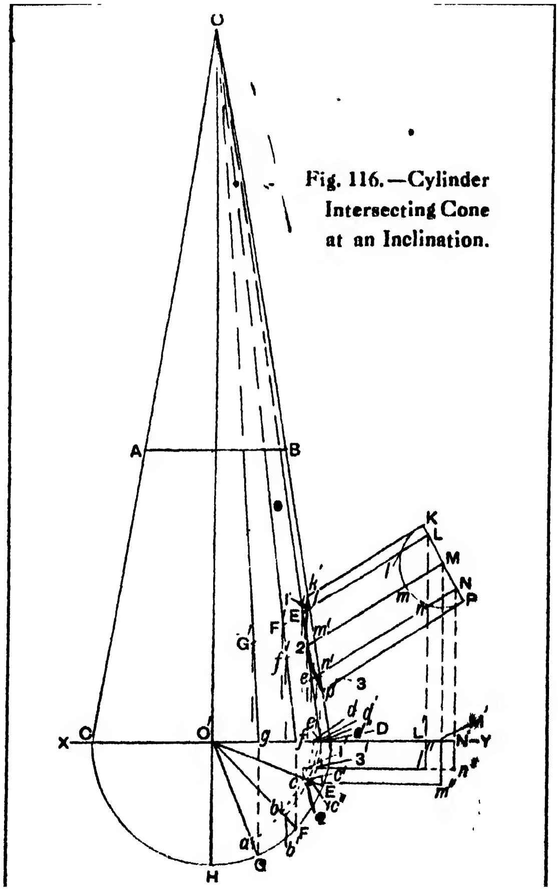


Fig. 116.—Cylinder Intersecting Cone at an Inclination.

obtain the point $2'$, and place this in elevation by drawing a vertical line from it, so as to cut the line Mm' produced in the point 2. Now from the point at which the parallel

line from n'' (which in this case is coincident with that from l'') intersects the curve $c''\,d''$ in the point $3'$, draw another vertical line to Nn' produced, so as to give the point 3 in elevation, and from k' draw a curve passing through the points 1, 2, and 3 to p', which thus gives the elevation of the curve of penetration. In order to avoid confusion, all the lines in the diagram are not fully drawn.

Patterns for Intersecting Cylinder with Oblique Conical Junction.– In the accompanying illustrations, ABCD (Fig. 117) represents a cylinder which has a branch EFGH attached by means of that part of an oblique cone represented by EJH. An elevation of the junction between the cone and the branch is represented by the line EH. The junction between the cone and the cylinder is represented by the curve ELJ, and this curve has first of all to be determined. Afterwards, developments or patterns for the various parts are required.

On the line EH describe a semicircle, divide it into four equal parts as at 1 2 3, and through the points of division draw the dotted lines to F. From a, b, and c on the line EH draw dotted lines at right angles to CD, to give the points a', b', and c' on the line DF$'$.

Describe a semicircle on the line CD, make $a'1'$ equal to $a1$, $b'2'$ equal to $b2$, and $c'3'$ equal to $c3$, and from F$'$ draw dotted lines through these points to touch the semicircle in the points d, e, and f, as indicated. From these latter points draw vertical dotted lines to cut the dotted lines aF, bF, and cF, produced in the points K, L, and M, and from E draw the curve to pass through M, L, and K to J, which is the junction required.

The pattern for the oblique cone part ELJH can now be set out.

First draw dotted lines parallel with EH, through M, L, K,

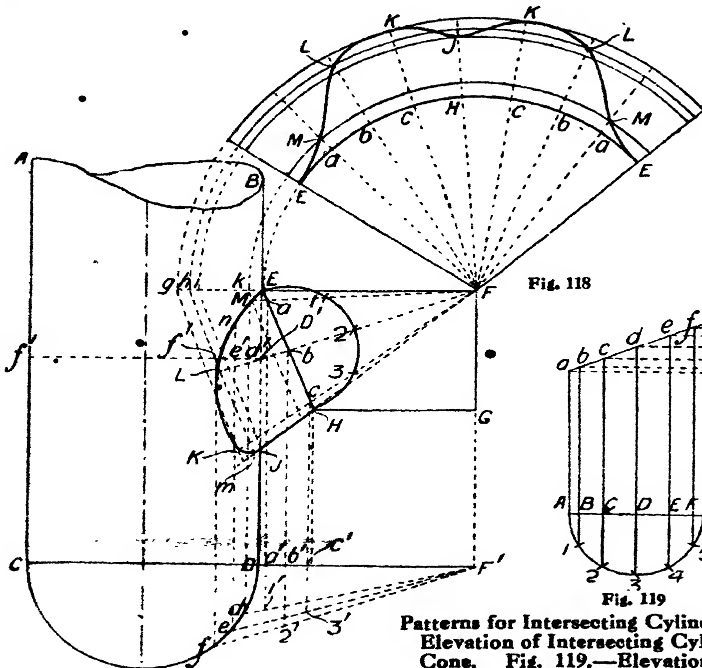


Fig. 117

Fig. 118

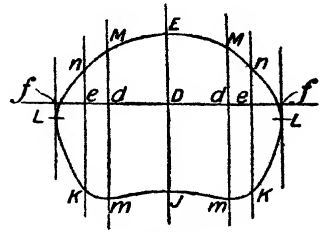


Fig. 121

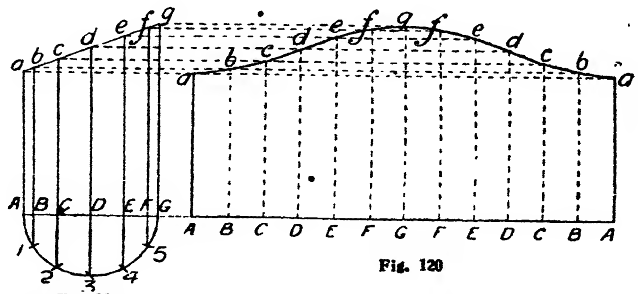


Fig. 119

Fig. 120

Patterns for Intersecting Cylinder with Oblique Conical Junction. Fig. 117.—Elevation of Intersecting Cylinders. Fig. 118.—Pattern for Part of Oblique Cone. Fig. 119.—Elevation of Branch Cylinder. Fig. 120.—Pattern for Branch Cylinder. Fig. 121.—Method of Setting Out Hole of Penetration.

and J, to give *k*, *i*, *h*, and *g*, on the line FE produced. Then with F as centre and radii equal respectively to FE, F*k*, F*i*, F*h*, and F*g*, describe arcs of circles. From E (Fig. 118) set off *a*, *b*, *c*, and H, etc., equal to twice the number of distances that are contained in the semicircle E2H (Fig. 117), and through these points thus obtained draw radial lines to F. A curve is now drawn as indicated through M, L, K, J, etc., to complete the pattern.

A pattern for the branch EFGH (Fig. 117) is now required, and in order to avoid confusion of lines an elevation of this part of the problem is shown at Fig. 119. First draw a semicircle on the line AG, divide it into six equal parts as at 1, 2, 3, 4, and 5, and from these points draw lines parallel with A*a*, in order to obtain the lengths A*a*, B*b*, C*c*, D*d*, etc. Now along the line AA (Fig. 120) set off B, C, D, etc., twice the number of distances that are contained in the semicircle A3G (Fig. 119). Thus AB (Fig. 120) equals A1 (Fig. 119), and so on.

Through A, B, C, D, E, F, and G (Fig. 120) draw vertical lines and transfer the lengths of lines marked coincidently from Fig. 119 to Fig. 120, as indicated. This may be done by drawing the dotted lines from *a*, *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 119) to cut the vertical lines in Fig. 120, in the points *a*, *b*, *c*, *d*, etc. A curve now drawn through these latter points gives the pattern required.

No pattern is shown for the ABCD part of Fig. 121, since none is required for a cylinder; but the hole of penetration is represented by Fig. 121.

To draw the true shape of this hole first draw two lines at right angles to each other as *ff* and EJ (Fig. 121). From D on each side of the central line make *def* equal to D*def* (Fig. 117). Make DE, *d*M and *en*, above the line *ff*, Fig. 121, equal to D′E, *d′*M, and *e′n* (Fig. 117). Similarly make DJ,

d m, *e* K, and *f* L, below the line *f f* in Fig. 121, equal respectively to D′J, *d′m*, *e′*K, and *f′*L (Fig. 117). A curve drawn through these points gives the hole required.

Pattern for Lip of Oil Measure.—Let A G *a g* (Fig. 122) represent an elevation of the lip for which a pattern is

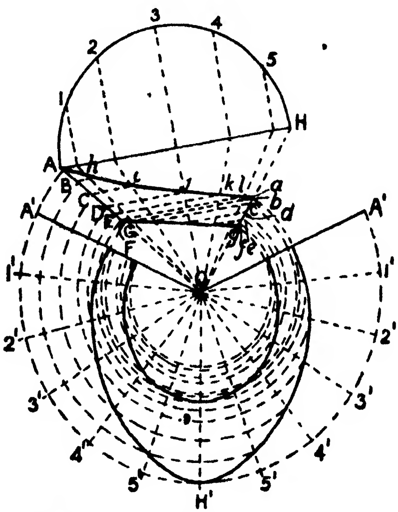


Fig. 122.—Pattern for Lip of Oil Measure.

required. Produce A G and *a g* to give the centre O, and produce *a g* so as to obtain the base line A H, which is drawn at right angles to the axis of the cone. On this base line describe a semicircle, which divide equally as at 1, 2, 3, 4, and 5, and from the latter points draw the dotted lines at right angles to the base line, continuing them as indicated to the centre O. Now from where these converging lines touch the top of the lip as at *h*, *i*, *j*, *k*, and *l*, draw lines

parallel with the base line A H, in order to obtain the points B, C, D, E, and F, on one side of the lip. Similarly, draw parallel lines from where the converging lines touch the bottom of the lip, in order to obtain the points *b*, *c*, *d*, *e*, and *f* on the other side of the lip. With O as centre, draw a series of dotted arcs from these points as illustrated, step off from A′ round the outside arc twice the number of distances that are contained in the semicircle A 3 H, and from the points thus obtained draw radial lines to the centre O. To draw the pattern, make a freehand curve from the arc G (beginning at the radial line A′O), passing from one arc to another in the distance between two radial lines. Similarly, repeat the method of working to obtain the smaller freehand curve by starting from the arc *g*, on the other side of the lip as indicated. Although the problem is a little involved, the illustration is to some extent self-explanatory, and a little careful study will render the method of working abundantly clear.

Pattern for Top of Jug.—Let A *a* B *b* (Fig. 123) represent an elevation, and A′ *a* E′ 3 B′ *b* a half-plan of the top of the jug. Divide the arc *a* 3 *b* into six equal parts, the arc A′E′ into three equal parts, the arc E′B′ into three equal parts, and draw the straight and dotted lines on the plan portion, as shown. To obtain the true lengths of the lines thus shown in plan, obtain C D E by running perpendiculars up from C′, D′, and E′ respectively. From B set off B′*c* equal to B′1, and draw the dotted line from B to *c*, which is the true length of the diagonal shown in plan as B′1. Similarly, set off from *c″* the distance *c″ c*, equal to C′1, and join C *c*, which is the true length of C′1. From *c″* set off *c″* C′, equal to *c′*2, and join with the dotted line to C. From *d′* set off *d′e*, equal to D′3, and join with a dotted line to D. From *d′* also set off *d′ d*, equal to D′2, and join D *d*. To draw the

pattern (Fig. 124), make B *b* equal to B *b* (Fig. 123); from B (Fig. 124) make B *c* equal to B *c* (Fig. 123); from *b* (Fig. 124) with compasses set to *b* 1 (Fig. 123) obtain the point *c;* from B (Fig. 124), with compasses set to B′C′ (Fig. 123), make an

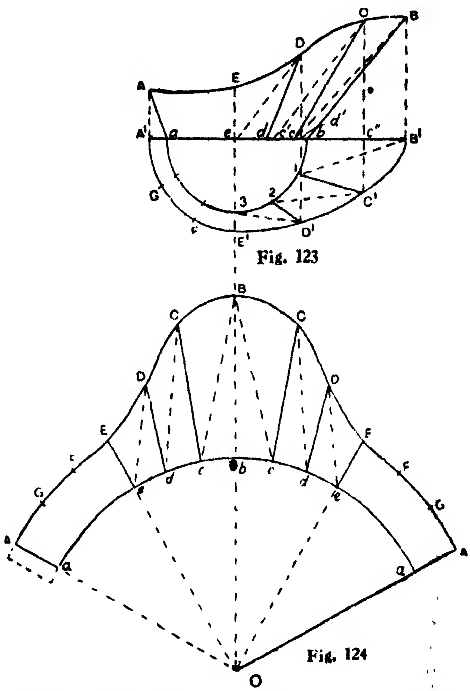


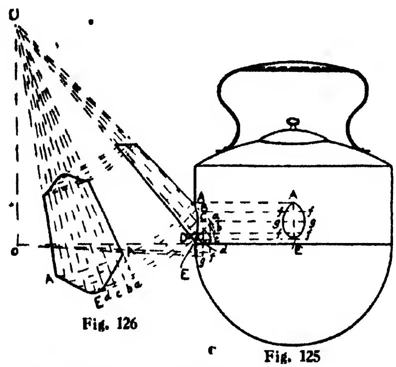
Fig. 123

Fig. 124

Figs. 123 and 124.—Pattern for Top of Jug.

arc, and from *c* (Fig. 124) with compasses set to C *c* (Fig. 123) obtain the point C. Continue this method of working on each side of the central line of the pattern, until the points D *d* and E *e* have been obtained (a little thought will render the mode of procedure quite clear), then unite E *e* on

each side of the central line, and produce the lines to give the centre O. With O as centre and radius equal to O E, describe the arcs as indicated, and step off from E (Fig. 124) the three divisions on each side, making them equal to E′, F′, G′, and A′ (Fig. 123), to obtain A B A *a b a* (Fig. 124), the pattern required. The dotted lines at one end of the pattern



Figs. 125 and 126.—Pattern for Kettle Spout.

represent an allowance for a lap seam; other working edges must be allowed if required.

Pattern for Kettle Spout.—Let Fig. 125 represent a kettle showing the spout for which a pattern is required. Before the pattern can be set out, certain points require to be fixed on the junction line of the spout and kettle; but many workers assume a junction line in order to avoid the trouble of obtaining one geometrically. However, if the spout is to be set out geometrically, the following method of working should be adopted. First produce the sides of the spout in order to obtain the apex O and the point *a*

(Fig. 125). The latter point, as illustrated, is situated at the base of the cone thus formed. Now draw the dotted semicircle on the line *a* E (Fig. 125), divide it equally as at *b*, *c*, and *d;* then unite these points to the apex by the straight dotted lines. Small vertical dotted lines are now drawn from the base line E *a* of the spout cone, and then continued below the bottom of the kettle, as illustrated. The points *f* and *g* (Fig. 125) are cut off below the bottom of the kettle to the same distances as are *b* and *c*, from the base line of the spout cone. A vertical line is dropped from O to give *o*, to which *f* and *g* are united. Upright lines are now drawn from where the latter lines cross the semicircle, which is described on the bottom of the kettle, until each meets its corresponding line on the kettle spout. Thus the point *g* is first obtained from the spout line O *c*, then an upright line is drawn from that point on *o g*, which touches the semicircle, until it again meets the spout line O *c* in the point C, which is one of fixed points on the junction line. The other points B and D are similarly obtained, and a curve is then drawn through A B C D E. A pattern for the spout is shown by Fig. 126, which is largely self-explanatory. A series of dotted arcs are drawn from a common centre O, as illustrated. The compasses are set to one of the divisions of the semicircle, say *a b* (Fig. 125), then starting from *a* (Fig. 126) step off four divisions *b*, *c*, *d*, and E, and from these points draw dotted lines to O (Fig. 126). A curve is now drawn from A to E (Fig. 125), passing from one arc to another in the space of one division; the other half of the spout is treated similarly, and so also is the end of the spout. The shape of the hole is shown at A, *f f*, *g g*, *f f*, and E (Fig. 125). To obtain this, project lines from A, B, C, D, and E, and make *f* and *g* on each side of the central line equal to the short lines *b* and *c*, which are drawn from the base of

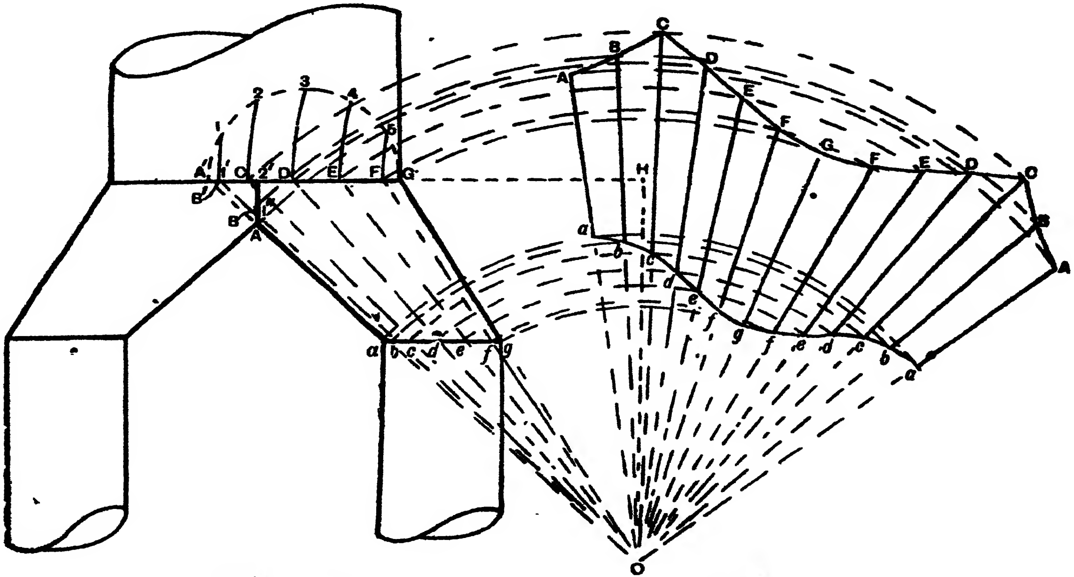


Fig. 127　　Fig. 128

Figs. 127 and 128.—Pattern for Tapering Breeches Piece.

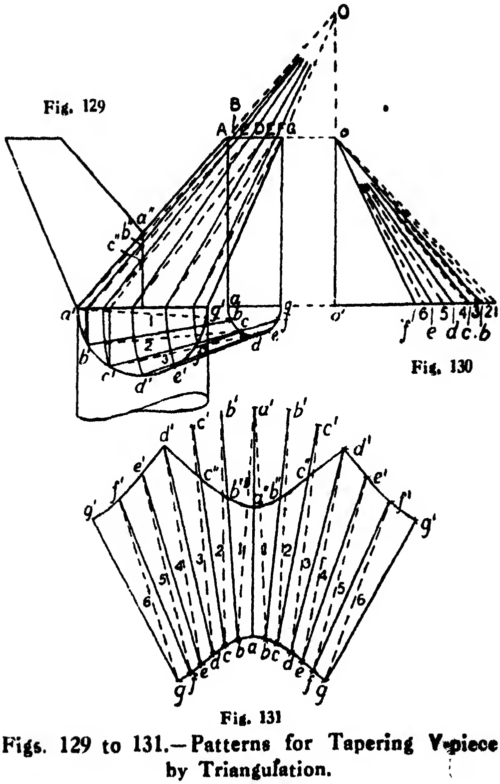
the small semicircle to the curve. A curve is drawn through the points thus obtained to give the shape of the required hole. Although the foregoing is the geometrical method of obtaining both the pattern and the shape of the hole, it is extremely doubtful if a workman would go to the trouble involved in setting them out, considering the comparative insignificance of the article, and bearing in mind that a near enough approximation for all practical purposes may be readily obtained by anyone familiar with the trade.

Pattern for Tapering Breeches Piece.—Let Fig. 127 represent the breeches piece for both tapering limbs, of which one pattern is required. On referring to the illustration, it will be seen that each tapering limb is really a portion of an oblique cone, therefore first construct the latter by producing A *a* and G *g* to give the complete cone A′ G O (Fig. 127). On the line A′ G (Fig. 127) describe a semicircle, which divide equally as at 1, 2, 3, 4, and 5. Now produce the base line A′ G to give H (shown within the pattern), which point is definitely fixed by erecting a perpendicular from O. With H as centre draw a series of arcs with the compasses from 1, 2, 3, 4, and 5 to give B′, C, D, E, and F on the base of the semicircle, and then unite these points to O with dotted lines, as indicated. From 1 draw the dotted line 1 1′; and from the latter point draw a radial line to O, until it cuts the central line A 2′ in the point 1″. Then from this point draw a short line parallel with A′ G to give B. To draw the pattern (Fig. 128), with O as centre draw a series of arcs from A, B, C, D, E, F, and G, *a*, *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 127) as indicated. Then, setting the compasses to one of the divisions of the semicircle, say 2, 3 (Fig. 127), start at A (Fig. 128), and step progressively to those arcs which were drawn from A, B, C, D, E, F, and G (Fig. 127) so as to obtain B, C, D, E, F, and G (Fig. 128).

Radial lines are now drawn from these latter points to O, in order to obtain *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 128). The points thus obtained are joined by drawing one curve from *a* to *a*, and another from A to A, as illustrated in Fig. 128.

Patterns for Tapering Y-piece by Triangulation.—Let Fig. 129 represent an elevation of the tapering **Y**-piece. A pattern is required to be set out for the tapering branch A G $a' g'$ by the method known as triangulation. This method is adopted when the apex of the cone O (Fig. 129) is for all practical purposes inaccessible; but the apex is here shown in order to better illustrate the relationship between the lines of the pattern, those of the plan, and those of the elevation. First drop perpendiculars from A G (Fig. 129) to give $a\,g$, then draw the semicircles $a\,d\,g$ and $a'\,d'\,g'$, and divide them equally as illustrated. Unite the points of division as at $b\,b'$, $c\,c'$, $d\,d'$, etc., and draw the dotted diagonals 1, 2, 3, etc, from a' to b, b' *to* c, c' to d, and so on. These lines and their dotted diagonals represent a series of plan lines which are related to those shown in elevation. The elevational lines may be obtained by first drawing arcs from *b*, *c*, *d*, *e*, and *f* to the base line, using o' (Fig. 130) as centre, and then uniting them to the apex of the cone O. But as the apex O is understood to be inaccessible, the true lengths of the elevational lines must be otherwise obtained. First make $o\,o'$ (Fig. 130) equal to the upright height of the branch; then set off from o' the distances *b*, *c*, *d*, *e*, and *f*. Thus, make $o'\,b$ (Fig. 130) equal to $b'\,b$ (Fig. 129), $o'\,c$ (Fig. 130) equal to $c'\,c$ (Fig. 129), and $o'\,d$, $o'\,e$, $o'\,f$ (Fig. 130) equal to $d\,d'$, $e\,e'$, and $f\,f'$ (Fig. 129), after which join *b*, *c*, *d*, *e*, and *f* (Fig. 130) to *o*. These lines now represent the true lengths of the elevational lines, and the diagonals are obtained similarly by making $o'\,1$ (Fig. 130) equal to the length of the first diagonal a' to b (Fig. 129), $o'\,2$ (Fig. 130)

equal to $b'c$ (Fig. 129), and so on until all are set off; then join them by dotted lines to o (Fig. 130). To draw the pattern, make $a'a$ (Fig. 131) equal to Aa' (Fig. 129). With a'



Figs. 129 to 131.—Patterns for Tapering V-piece by Triangulation.

(Fig. 131) as centre, and compasses set to $a'b'$ (Fig. 129), draw an arc; with a (Fig. 131) as centre, and $a\,b$ (Fig. 129) as radius, draw another. With a' (Fig. 131) as centre, and compasses set to the dotted diagonal $o\,1$ (Fig. 130), cut the

latter arc to obtain *b* (Fig. 131); then with the latter point as centre, and *o b* (Fig. 130), as radius, cut the first arc to obtain *b′* (Fig. 131). Repeat this method of working until all the points except *g′ g* (Fig. 131) are obtained (the latter length is transferred from Fig. 129), and join the points of division as indicated. The junction points are now obtained. Draw straight vertical lines from *b′* and *c′* (Fig. 129) to the base line, and from thence draw dotted lines to the central line as indicated. Short lines are now drawn from these points on the central line and at right angles with it, in order to obtain the points *b″* and *c″* respectively. Make *a a″*, *b b″*, and *c c″* (Fig. 131) equal to A *a″*, B *b″*, and C *c″* (Fig. 129) and draw a curve through the points thus obtained to complete the pattern.

Pattern for Oblique Tapering Y-piece having Rectangular Base.—Let Fig. 132 represent an elevation and part plan of the oblique tapering Y-piece. From the plan it will be seen that the branch tapers obliquely, so that the back will fit against the wall. Divide the circle into twelve equal parts, and join them to the four corners of the rectangle as indicated. The true lengths of these lines are now obtained by setting off their respective distances from *o* (Fig. 132) as illustrated, and then joining them by dotted lines to O. To draw the pattern (Fig. 133), make C D equal to C D (Fig. 132), make C 7, C 6, C 5, and C 4 (Fig. 133) equal respectively to O 7, O 6, O 5, and O 4 (Fig. 132), and make the distances 7, 6, 5, and 4 (Fig. 133) equal to 7′, 6′, 5′, and 4′ (Fig. 132). Make 4 B (Fig. 133) equal to O 4′ (Fig. 132), then with C B (Fig. 132) as radius, and C (Fig. 133) as centre, cut the last line to obtain B (Fig. 133). Make B 3, B 2, B 1 (Fig. 133) equal to O 3, O 2, O 1 (Fig. 132); make the distances 4, 3, 2, and 1 (Fig. 133) equal to 4′, 3′, 2′, and 1′ (Fig. 132). With B (Fig. 133) as centre, make B A equal to B A (Fig. 132); then

with 1 (Fig. 133) as centre, and radius equal to O 1 (Fig. 132) cut the line to obtain A (Fig. 133). Make the distance from the base line CD to c (Fig. 133) equal to Cc (Fig. 132)

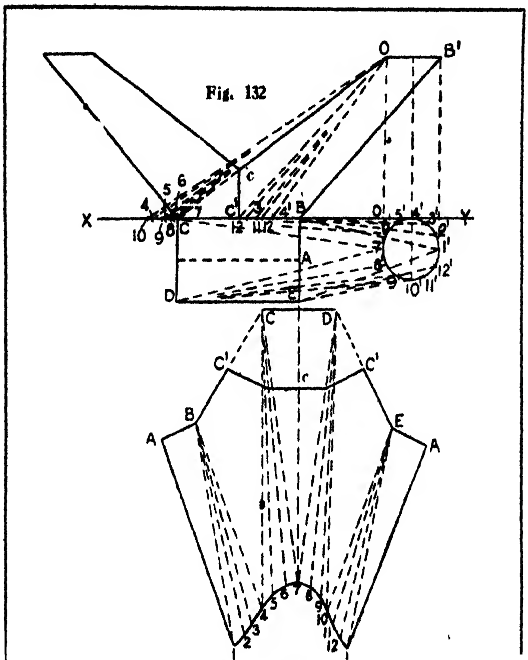


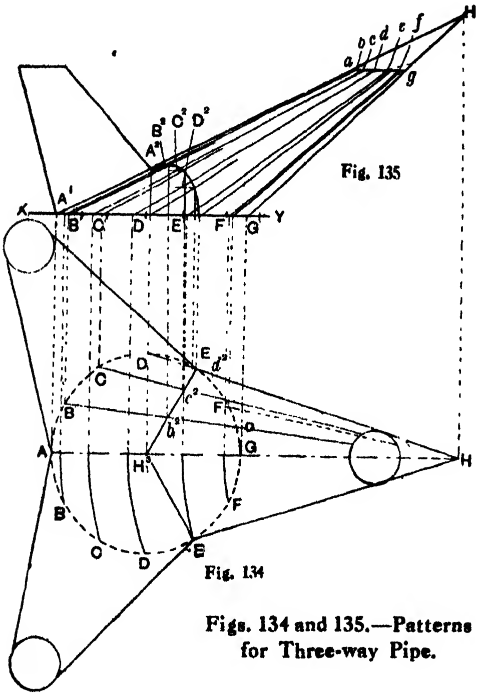
Fig. 133

Figs. 132 and 133.—Pattern for Oblique Tapering Y-piece having Rectangular Base.

and draw a line through c (Fig. 133) parallel with CD; make BC′ (Fig. 133) equal to BC′ (Fig. 132). Unite ABC′ with straight lines, and draw a curved line from 1 to 7, as indicated. This completes one-half of the pattern, and the other half is obtained similarly.

Patterns for Three-way Pipe.—In setting out the draw-

ings to obtain the patterns for three equal oblique cones joining the horizontal section of a cylinder, first draw a plan to the required size, as at Fig. 134. Divide the base circle into, say, twelve equal parts, as A, B, C, etc., and



Figs. 134 and 135.—Patterns for Three-way Pipe.

draw projectors from the division points on the top half of the circle to the ground line XY. From A^1 (Fig. 135) set off a line inclined at the required angle to represent the longest generating line on the surface of one cone. Make $A^1 a$ equal to the length required, and from a draw a line

parallel to the ground line. Make $a\,g$ equal to the desired diameter for the smaller end of the cone, and join g to G^1. Produce $A^1 a$ and $G^1 g$ to meet at H^1, the apex of the cone. Draw a projector from H^1 to the centre line of the plan, and join A, B, C, etc., to H, the point found; also join the elevations of the division points shown along the ground line, by straight lines, to the apex of the cone. Where the plans of these lines A, B, C, etc., pass through the section line $E\,H^3$ in the plan, draw projectors from b^2, c^2, d^2 to join the elevational lines with corresponding letters. A curve drawn from A^2 through these points as shown would be the elevational curve of the section, where the cones join. To find the true slant of the elevational lines, use H on the plan as centre, and with radius to B, C, D, E, F, on the lower half of the plan, draw arcs of circles to the centre line. Draw projectors from the ends of the arcs to the ground line; join these points to the apex of the cone, and the lengths found will be the true slants, or generating lines for developing the cone pattern. From the points through which the section curve passes, on the elevation lines, draw lines parallel to the ground to cut the generating lines and give the points B^2, C^2, D^2 (Fig. 135). In working the pattern take $A^1 H^1$ (Fig. 135), and mark upon a straight line as at A H (Fig. 136). Next take the length of the generating line $H^1 B^1$ as radius, and using H on the pattern (Fig. 136) as centre, draw an arc. With the plan division distance A B as radius, and using A on the pattern as centre, cut the arc last drawn to give the point B. With the length of the generating line $H^1 C^1$ as radius, and again using H on the pattern as centre, draw an arc. Take the plan division distance B C as radius, and using B on the pattern as centre, cut the arc last drawn to give C. Repeat this method of working on each side of the centre line A H,

until the remaining points D, E, F, G are added. Draw a curve through these points to form the base curve of the cone pattern. Join A, B, etc., by straight lines to H. Now take H^{1}a from the elevation, and mark off from H to give *a* on AH (Fig. 136); then take H^1 *b*, *c*, *d*, *e*, *f*, and *g* alternately, and mark off from H on the pattern to give the

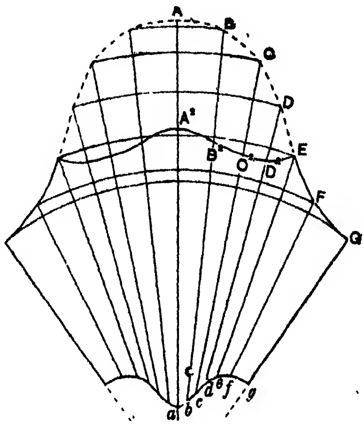


Fig. 136.—Development of Pattern for Three-way Pipe.

points *b*, *c*, *d*, etc. A curve drawn through these points would form the top part of the pattern. Next take H^1 A^2 from the elevation, and set off from H to give A^2 on the pattern. Take H^1 and B^2, C^2, D^2 alternately, and, using H on the pattern as centre, cut the lines with corresponding letters to give the points B^2, C^2, D^2. A curve drawn through these points to E would give the curve for the pattern at the section line.

CHAPTER V

Oval Problems

Pattern for Oval Elbow.—First draw an elevation of the elbow to the required angle, as in Fig. 137, and let the dotted outline from *a* to *g* represent a half-plan or a half-section of the pipe. Divide the curve *bf* (Fig. 137) equally as at *c*, *d*, and *e*, and from the points thus obtained draw the dotted perpendiculars in order to obtain C, D,

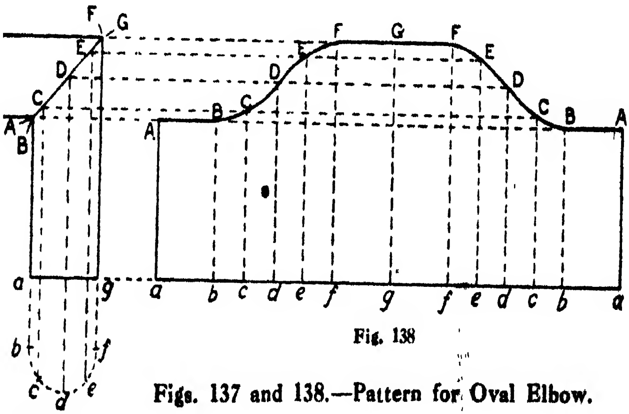


Fig. 138

Fig. 137

Figs. 137 and 138.—Pattern for Oval Elbow.

and E on the junction line. To draw the pattern (Fig. 138), step off along the straight line *aa* twice the number of distances that are contained in the half-plan (Fig. 137), and from the points thus obtained (*a*, *b*, *c*, *d*, *e*, *f*, and *g*) draw the dotted perpendiculars as indicated. A series of dotted lines are now projected from the points on the junction line of the elbow in Fig. 137 to cut the dotted

perpendiculars as illustrated, and a line drawn to pass through the points obtained completes the pattern. It will be noted that the dotted line from *b* (Fig. 137) coincides with *a*. Therefore, in the pattern A*a* and B*b*

Fig. 139

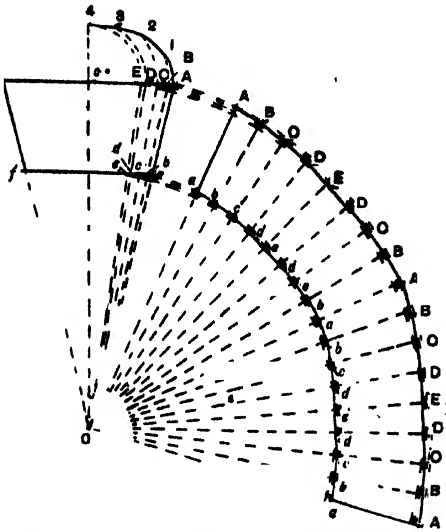


Fig. 140

Figs. 139 and 140.—Pattern for Oval Bread-tin.

are of equal length. Similarly the dotted line from F coincides with G (Fig. 137), and this accounts for F*f* and G*g* (Fig. 138) being of equal length. The foregoing method of obtaining the pattern is applicable to either a square or bevelled elbow.

Pattern for Oval Bread-tin.—Let F A *f a* (Fig. 139) represent an elevation and 4 3 2 1 A *o* a quarter plan of the

top of an oval bread-tin. First divide the arc A 4 (Fig. 139) equally, as at 1, 2, and 3, then with *o* as centre, describe a series of dotted arcs from the latter points in order to obtain B, C, D, and E. Produce A *a* and F *f* to obtain O, then join B, C, D, and E to O, so as to obtain *b*, *c*, *d*, and *e*. To draw the pattern (Fig. 140), describe a series of dotted arcs from A, B, C, D, E, *a*, *b*, *c*, *d*, and *e* (Fig. 139), using O as centre. Then with the compasses set to A 1 (Fig. 139), start at A (Fig. 140) and step off the divisions B, C, D, and E, as indicated, passing from one dotted arc to another in the space of one division. As the quarter plan A 4 (Fig. 139) contains four divisions, four times this number will be required for the whole plan, and, consequently, for the pattern; hence, sixteen divisions must be stepped off from A (Fig. 140) as illustrated. Radial lines are now drawn from these sixteen divisions to O, and the pattern is completed by drawing two curves, one from A to A, and the other from *a* to *a* (Fig. 140), passing from arc to arc in the space of one division, as shown in the illustration. The working edges required will be a wiring edge for the top, edges for a grooved seam at the sides, and a small edge for a knocked-up bottom; and these must be added to the pattern before cutting it out.

Patterns for Tapering Oval Coal-bucket.—In the accompanying illustrations, Fig. 141 shows a tapering oval coal-bucket complete. A, F, *a′*, and *f′* (Fig. 142) represent a side elevation with seams corresponding to the line E *e′*, whilst Fig. 143 shows the method of obtaining the slant lengths.

It will be best, first of all, to deal with that part of the elevation represented by *a*, *f*, *a′*, and *f′*, a half plan of which is *a*, *e′*, *f*, *f′*, *e*, and *a′* (Fig. 144), and then the upper portion can be afterwards added. Divide the

arcs of the half plan as indicated at *b b′*, *c c′*, and *d d′*, and join them with straight lines. Then draw the dotted diagonals from *a′* to *b*, *b′* to *c*, *c′* to *d*, *d′* to *e′*, represented by the figures 1, 2, 3, and 4 (Fig. 145). The plan lengths *b b′*, *c c′*, and *d d′* are now placed on the elevation. From *d′* (Fig. 144) draw a dotted upright to give the point *d′* (Fig. 142), from *d* (Fig. 144) draw another to give the

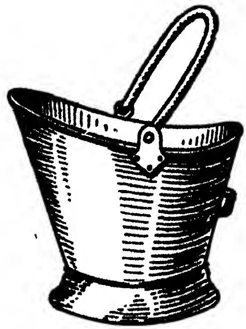


Fig. 141.—Complete Coal-bucket.

point *d* (Fig. 142); join *d′ d* (Fig. 142), and produce to give the point D also. Then *d d′* (Fig. 142) is the elevation of the plan line *d d′* (Fig. 144). Continue this method of working until the other lines have been obtained. To obtain the true slant lengths of these elevational lines, from O′ (Fig. 143) set off *a*, *b*, *c*, *d*, *e*, equal respectively to the plan lengths *a a′*, *b b′*, *c c′*, *d d′*, and *e e′* (Fig. 144). Similarly from O′ (Fig. 143) set off 1, 2, 3, 4, equal respectively to the dotted diagonals 1, 2, 3, and 4 (Fig. 144), and join them to O (Fig. 143).

To draw the pattern Fig. 145, make *a a′* equal to

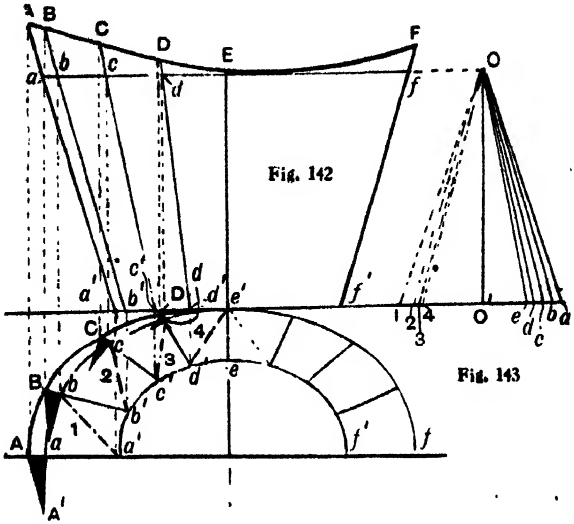


Fig. 142

Fig. 143

Fig. 144

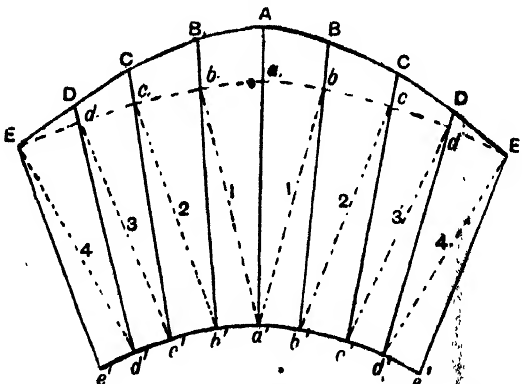


Fig. 145

Figs. 142 to 145.—Patterns for Tapering Oval Coal-bucket. Fig. 142.—Elevation. Fig. 143.—Method of Obtaining Slant Lengths. Fig. 144.—Half Plan. Fig. 145.—Half Pattern for Body.

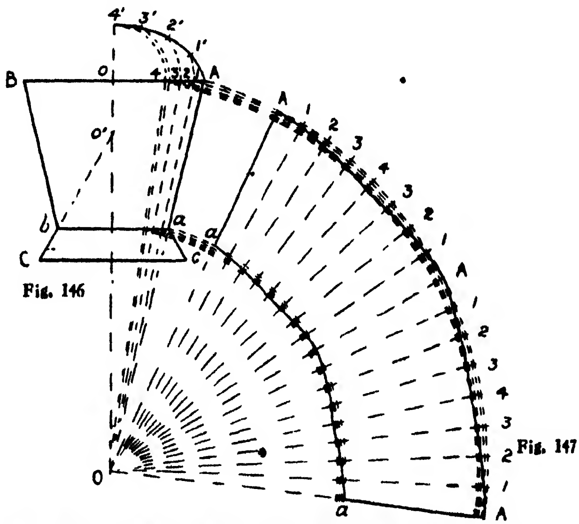
O *a* (Fig. 143), and with *a* (Fig. 145) as centre, and *a b* (Fig. 144) as radius, draw an arc on each side. With *a′* (Fig. 145) as centre, and *a′ b′* (Fig. 144) as radius, again draw arcs on each side. From the same centre, and radius equal to O 1 (Fig. 143), the first diagonal, draw arcs to cut those previously made in the points *b*, and with these latter points respectively as centres, and O *b* (Fig. 143) as radius, draw arcs to cut those previously made to give the points *b′ b′*. This method of working is continued until all the points have been obtained, as indicated in the pattern. Unite these points with curved lines to complete the pattern represented in elevation by *a*, E, *a′*, *e′* (Fig. 142).

The top part of the pattern now requires to be added. From A, B, C, and D (Fig. 142) draw perpendicularly the dotted lines, and produce *a a′*, *b b′*, *c c′*, and *d d′* (Fig. 144) to give respectively the points A, B, C, and D (Fig. 144); join these with the curved line as illustrated. The true lengths of A*a*, B*b*, C*c*, and D*d* are now obtained, and added to the pattern as follows: Draw a line at right angles with *a a′* (Fig. 144), making it equal to the upright height of A*a* (Fig. 142), and join it to A (Fig. 144). Then A A′ (Fig. 144) will be the length of A*a* (Fig. 145), which is added to the pattern. The other lengths are obtained and added similarly. Draw a curved line to touch the points thus marked on the pattern to complete it.

The pattern for the back of the bucket is drawn in a similar way, and in this instance the only difference between the front and back patterns is in the top part, because the elevation A*a*E (Fig. 142) is greater than E F *f*.

Pattern for Tapering Oval Bucket.—Let B*a b a* C*c* (Fig. 146) represent an elevation of the oval bucket for which a pattern is required. First draw a quarter plan of the top, as at A 4′ O; divide the arc A 4′ equally as 1′, 2′

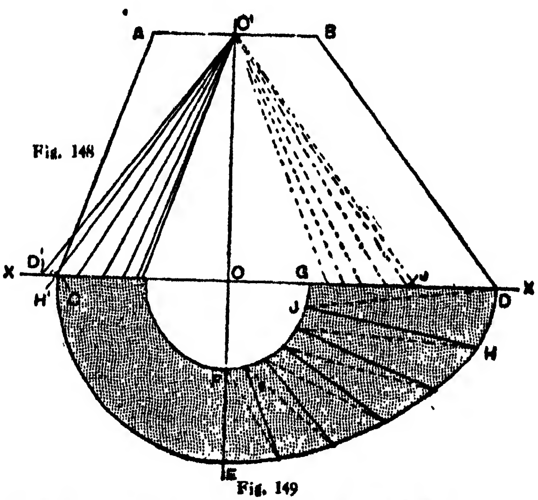
and 3′, then with O as centre describe a series of dotted arcs from the points of division, as illustrated, in order to obtain a series of points, 1, 2, 3 and 4 on the top of the bucket. Produce A *a* (Fig. 146) to obtain o, then join 1, 2, 3



Figs. 146 and 147.—Pattern for Tapering Oval Bucket.

and 4 (Fig. 146) to o with dotted lines, in order to obtain a series of points on the bottom of the bucket. With o as centre, draw a series of dotted arcs (Fig. 147) from 1, 2, 3 and 4 (Fig. 146). With the same centre, draw also another series of dotted arcs from *a*, and the other points on the bottom of the bucket (Fig. 146). Now set the compasses to one of the plan divisions (say A1′, Fig. 146), then beginning at A (Fig. 147) set off sixteen divisions, as shown, passing from one arc to another in the space of

one division. Radial lines are now drawn from these points, A, 1, 2, 3 and 4, and so on (Fig. 147) to O. Curves are then drawn from A to A (Fig. 147), and from *a* to *a* to complete the pattern. When drawing the curves take care to pass from one arc to another in the space of one division. A pattern for the foot may be obtained similarly.



Figs. 148 and 149.—Pattern for Egg-shaped Scoop.

Join C and *b* to *o'* (Fig. 146), and obtain the pattern by following the same method of working as that adopted for obtaining the body pattern.

Pattern for Egg-shaped Scoop.—Let ABCD (Fig. 148) represent the elevation of the Scoop; Fig. 149 shows shaded a half-plan. A pattern is required for the front portion of the scoop, one half of which is shown at DEFG (Fig. 149). First divide the two arcs DE and FG into six equal parts

as shown, joining up the points as indicated by the full and dotted lines H J, D J, and so on; and along the ground line X X, from O, set off on the left side distances equal to the full lines D G, H J, etc., and from each draw lines to o' (Fig. 148). These lines D′O′, etc., represent the true slant lengths of D G, H J, etc., marked on the plan. Similarly on the right-hand side of O, set off the diagonal

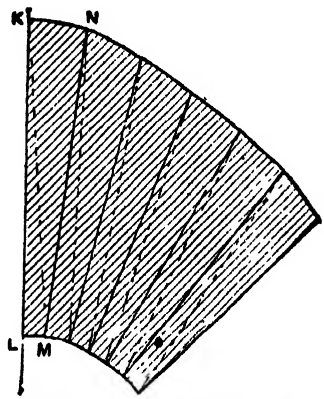
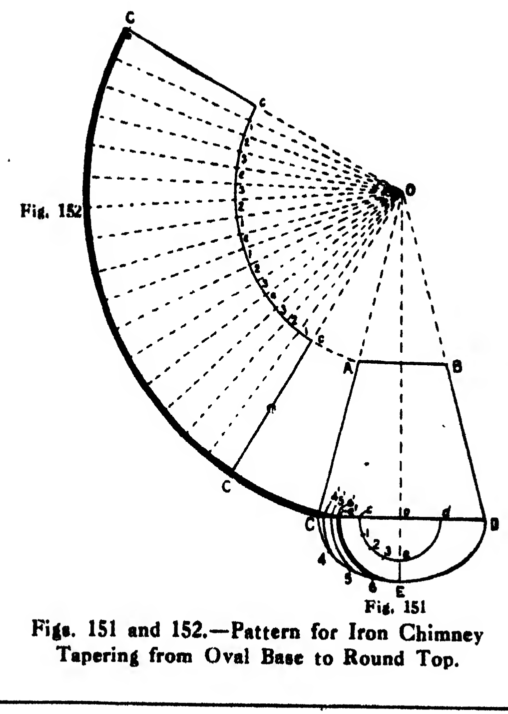


Fig. 150.—Pattern for Egg-shaped Scoop.

distances equal to the dotted lines in Fig. 149, D J, etc., and draw lines from these to O′ (Fig. 148). These dotted lines O′J′, etc., in Fig. 148 now represent the true lengths of the dotted diagonal lines shown on the plan. To develop the pattern (Fig. 150), draw a straight line K L, and make it equal to D′O′ (Fig. 148). From K (Fig. 150) as centre, with radius equal to D H (Fig. 149), describe a small arc. Similarly with L (Fig. 150) as centre, and with radius equal to G J (Fig. 149), describe another arc. With K (Fig.

150) as centre, and radius equal to the diagonal O′J (Fig. 148), describe an arc to cut the arc previously described to give the point M. Then with M (Fig. 150) as centre, and with radius equal to H′O′ (Fig. 148), describe an arc to give the point N (Fig. 150)). Repeat this method of



Figs. 151 and 152.—Pattern for Iron Chimney Tapering from Oval Base to Round Top.

working, using the next corresponding diagonal, plan distances, and true slant length, until all the points in Fig. 150 have been obtained. Lines are now drawn through these points to give one half of the front pattern required. The other half is similarly developed.

Oval Problems

Pattern for Iron Chimney Tapering from Oval Base to Round Top.—Let ABCD (Fig. 151) represent an elevation, and C*c*, D*d*, E*e* a half-plan of the chimney. Divide the arcs CE and *ce* respectively into four equal parts as at 1, 2, 3, 4, 5, 6. Then with *o* as centre, describe the arcs from 4, 5, 6 and E until they touch the ground line CD, as indicated at 4′, 5′, 6′, *e*′. With O as centre and OA as radius, draw the arc *cc* (Fig. 152), and on it set off four times the number of distances that are contained in the arc *ce* (Fig. 151), after which draw the dotted radial lines through the points of division. Now with O as centre, and OC, O4′, O5′, O6′ and O*e*′, as radii respectively, draw the series of arcs as shown in Fig. 152. The curve CC (Fig. 152) is now drawn to pass from one arc to another between every two points of division; then CC, *cc* (Fig. 152) is the pattern required. The same principle may be adopted in setting out the pattern for a chimney tapering from a round base to an oval top. A careful study of the foregoing will reveal the necessary adaptation required.

Pattern for Body Tapering from Oval to Round by Triangulation.—Let Fig. 153 represent a side elevation and half-plan of the tapering body for which a pattern is required. First divide the arc AE into a number of equal parts, as at B, C and D. Similarly divide the arc *a*′*e* equally, as at *b*, *c* and *d*. Join B*b*, C*c*, D*d* and E*e*, then draw the dotted diagonals 1, 2, 3 and 4 as illustrated. Before the pattern can be drawn, the true elevational lengths of these diagonals, and also the true elevational lengths of the plan lines B*b*, C*c*, D*d* and E*e* must be ascertained, as follows: Make O*o* (Fig. 154) equal to the upright height of the body, and from *o*, along the base line, set off the distances 1, 2, 3 and 4, making them respectively equal to the lengths of the dotted diagonals 1, 2, 3 and 4

(Fig. 153). Now make *o b* (Fig. 154) equal to B *b* (Fig. 153); make *o c*, *o d*, *o e* (Fig. 154) equal respectively to C *c*, D *d* and E *e* (Fig. 153), then join all the points thus obtained on the base line of Fig. 154 to O. O *b* (Fig. 154)

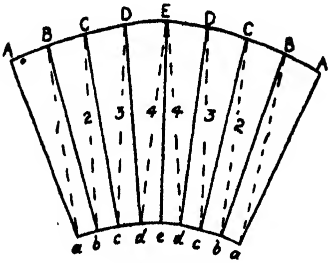


Fig. 155

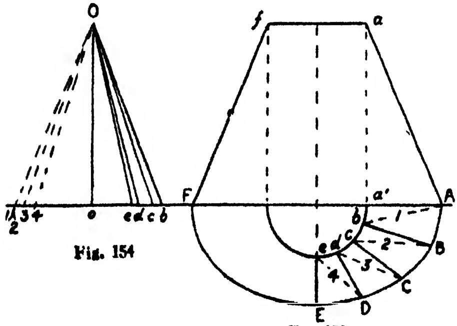


Fig. 153

Figs. 153 to 155.—Pattern for Body Tapering from Oval to Round.

then becomes the true elevational length of B *b* (Fig. 153): O 1 (Fig. 154) is the true elevational length of the dotted diagonal marked 1 in Fig. 153; and so on with regard to the others. To draw the pattern (Fig. 155), make A *a*

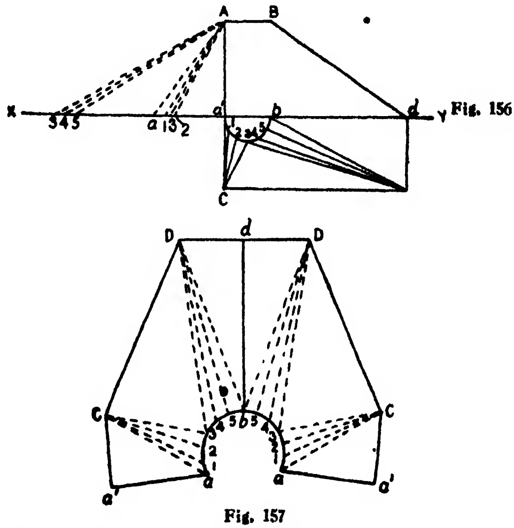
equal to A *a* (Fig. 153); make AB and *a b* (Fig. 155) equal to AB and *a′ b* (Fig. 153); make *a* B (Fig. 155) equal to o 1 (Fig. 154); and make B *b* (Fig. 155) equal to o *b* (Fig. 154). Now make BC and *b c* (Fig. 155) equal to BC and *b c* (Fig. 153); make *b* C (Fig. 155) equal to o 2 (Fig. 154); and make C *c* (Fig. 155) equal to o *c* (Fig. 154). Make CD and *c d* (Fig. 155) equal to CD and *c d* (Fig. 153); make CD (Fig. 155) equal to o 3 (Fig. 154); and D *d* (Fig. 155) equal to o *d* (Fig. 154). Make DE and *d e* (Fig. 155) equal to DE and *d e* (Fig. 153); make *d* E (Fig. 155) equal to o 4 (Fig. 154) and E *e* (Fig. 155) equal to o *e* (Fig. 154). A curve drawn from A to E, passing through B, C and D, and another drawn from *a* to *e*, passing through *b*, *c* and *d* (Fig. 155) gives AE *a e* (Fig. 155), which is a pattern for one-quarter of the body shown in plan at A *a′* E *a* (Fig. 153). The complete pattern for the body consists of four of these quarter patterns, of course; but as they are all identical, there is only need to draw one and then repeat for the remaining three. Fig. 155 shows two quarter-patterns joined together, this being a pattern for one-half of the body. If the body is made of two halves resembling Fig. 155, the seams will occur at *f* F and *a* A (Fig. 153). A complete pattern will be twice that shown by Fig. 155.

CHAPTER VI

Hoods, Hoppers and Chutes

Pattern for Square to Round Tapering Hood with Flat Back.—Let AB$a'd$ (Fig. 156) represent an elevation, and $a'bd$DC a half plan of the hood. Divide the semicircle $a'3b$ into six equal parts, and from the points of division draw lines to the corners C and D as indicated. To obtain the true lengths of these plan lines, set off from a' the distances $a'a$, $a'1$, $a'2$, and $a'3$ respectively, equal to Ca', C1, C2, and C3, and join them by the dotted lines to A. Similarly from a', set off $a'3$, $a'4$, and $a'5$, making them equal respectively D3, D4, and D5, and join these by dotted lines to A. These dotted lines now represent the true elevational lengths of the lines shown in plan; thus A3 is the true length of C3, and A5 of D5. To set out the pattern (Fig. 157) set off on each side of the central line db the distances dD, equal to dD (Fig. 156). Make db (Fig. 157) equal to Bd (Fig. 156); then with the compasses set to one of the divisions of the semicircle, and with b (Fig. 157) as centre, describe a small arc. With compasses set to A5 (Fig. 156), and with D (Fig. 157) as centre, cut the small arc to obtain the point 5 in the pattern. Repeat this method of working until D3 on the pattern has been obtained. Then with compasses set to DC (Fig. 156), and with D (Fig. 157) as centre, describe an arc close to C. With 3 (Fig. 157) as centre, and with radius equal to A3 (Fig. 156), cut this arc to obtain the point C on the pattern. With the compasses set to one of the divisions of the

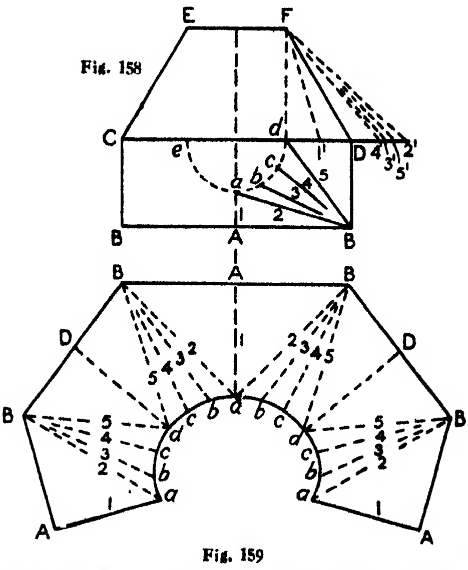
semicircle, and with 3 (Fig. 157) as centre, make another arc. With C (Fig. 157) as centre, and radius equal to A 2 (Fig. 156), cut this arc to obtain the point 2 on the pattern. Obtain the points 1 and *a* similarly. Then with C (Fig. 157) as centre, and radius equal to C*a′* (Fig. 156),



Figs. 156 and 157.—Pattern for Square to Round Tapering Hood with Flat Back.

make an arc; with *a* (Fig. 157) as centre, and radius equal to A*a′*, cut this arc to obtain *a′* on the pattern. Join *a a′*, *a′* C, C D, and D D with straight lines, and draw a curved line to pass through the points 1, 2, 3, 4, 5, *b*, etc., to complete the pattern. The dotted lines need not be marked on the work; they are shown here only to render the method of working clearer.

Pattern for Body Tapering from Oblong to Round.—Let EFCD (Fig. 158) represent an elevation, and C*ed*DBAB a half-plan of the body referred to. First divide the quadrant *ad* equally as at *b* and *c*, and join these points to B as indicated by the plan lines 2, 3, 4, and 5.



Figs. 158 and 159.—Pattern for Body Tapering from Oblong to Round.

The true elevational lengths of these plan lines must now be obtained by setting out their respective lengths from *d* (Fig. 158) along the base line, as illustrated by 1′, 2′, 3′, 4′ and 5′, and then joining them by the dotted lines to F (Fig. 158). Thus F 1′ equals the plan line 1, in elevation; F 2′ equals the elevational length of the plan line 2, and

so on. To draw the pattern (Fig. 159), make BAB (Fig. 159) equal to BAB (Fig. 158), make Ba (Fig. 159) equal to F2′ (Fig. 158), and make $a\,b$ (Fig. 159) equal to $a\,b$ (Fig. 158). From B (Fig. 159), with compasses set to F3′ (Fig. 158), cut the point b (Fig. 159); then with $a\,b$ as radius and b as centre make an arc in the neighbourhood of c (Fig. 159). With B as centre and radius equal to F4′ (Fig. 158), cut the arc to obtain c. Similarly make $c\,d$ (Fig. 159) equal to $b\,c$; then with B as centre and radius equal to F5′ (Fig. 158), definitely fix the point d (Fig. 159). With B (Fig. 159) as centre and BD (Fig. 158) as radius, make an arc in the neighbourhood of D (Fig. 159); then with FD (Fig. 158) as radius and d (Fig. 159) as centre, cut the arc to obtain D. The other points are obtained similarly, but in the reverse order, as may be seen from the lettering in Fig. 159. After obtaining all the points a curve is drawn from a to a, passing through b, c, d, c and b (Fig. 159), and the outer points are joined together by straight lines.

Pattern for Unequal Tapering Hopper.—First draw the plan ABCD, $a\,b\,c\,d$ (Fig. 160), and draw the dotted diagonals as shown. The true slant lengths of the corners Aa, Bb, Cc, Dd, and the dotted diagonals E, F, G, and H (Fig. 160) are next required. Draw a line XX (Fig. 161), and at right angles to it draw another line A′B′, and make A′B′ equal to the required depth of the hopper. To the left of A′, on the line XX, make A′a' equal to Aa (Fig. 160); make A′d', A′b', A′c' (Fig. 161) each equal respectively to Dd, Bb, and Cc (Fig. 160), and draw lines to B′ (Fig. 161). These are the true lengths of the different corners. To the right of A′ (Fig. 161), along the line XX, make A′E′, A′F′, A′G′, and A′H′ each equal respectively the diagonals EFGH (Fig. 160), and draw lines from these points E′F′G′H′ (Fig. 161) to B¹. These are the true lengths of the diagonals.

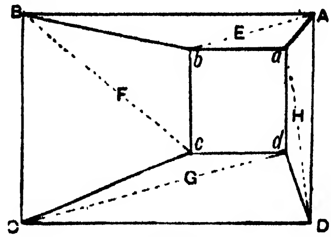


Fig. 160

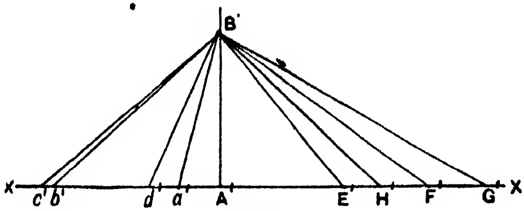


Fig. 161

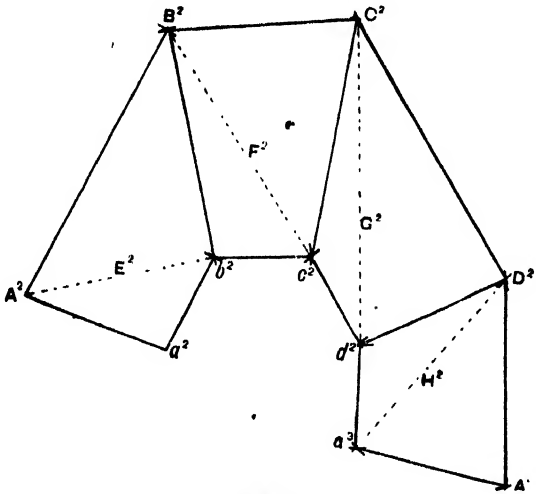


Fig. 162

Figs. 160 to 162.—Pattern for Unequal Tapering Hopper.

To draw the pattern (Fig. 162), which is in one piece, having the seam at A a (Fig. 160), first draw a straight line $A^2 a^2$ (Fig. 162) equal to $B' a'$ (Fig. 161). With A^2 (Fig. 162) as centre and A B (Fig. 160) as radius, draw a small arc, and with a^2 (Fig. 162) as centre and $a\,b$ (Fig. 160) as radius draw another arc. Now with A^2 (Fig. 162) as centre and $B' E'$ (Fig. 161) as radius draw a small arc so as to cut at the point b^2 (Fig. 162) the arc that was previously made. With b^2 (Fig. 162) as centre and $B' b'$ (Fig. 161) as radius cut the remaining arc in the point B^2 (Fig. 162). Repeat this method of working in order to get the remaining points $C^2 c^2$, $D^2 d^2$, $A^3 a^3$, and unite them with straight lines, which then gives the pattern required. The dotted lines E^2, F^2, G^2, and H^2 in Fig. 162 also show the true length of the diagonals in Fig. 160. The join of the pattern is consequently represented by the two lines $A^2 a^2$, $A^3 a^3$.

Pattern for Chute.—Let $a\,d\,d'$ D (Fig. 163) represent an elevation, and d' D A a' B C a half-plan of the chute for which a pattern is required. On the line $a\,d$ (Fig. 163) describe a quarter circle, which divide equally as at 1, 2, and 3. Then draw the dotted lines from the points thus obtained, at right angles with $a\,d$ in order to obtain $b\,c$. From a, b, c, and d draw the perpendicular dotted lines to obtain a', b', c', and d' on the half-plan. Then draw another series of dotted lines to obtain a'', b'', c'', and d'' on the dotted line O o, as illustrated. Next draw the dotted diagonals 2′, 3′, 4′, and 6′ (shown in plan), and along the base line from o set off the respective lengths of these diagonals, and also the plan line a' B, in order to obtain 2″, 3″, 4″, 5″, and 6″. Unite these latter points to a'', b'', c'', and d'' in the same order as they are shown marked in plan. Thus, in plan, the dotted diagonal 2′ is united to a'. Therefore unite 2″ to a''; similarly, the dotted

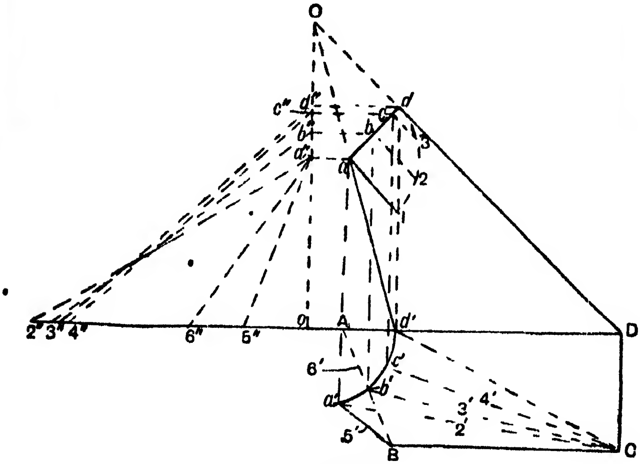


Fig. 163

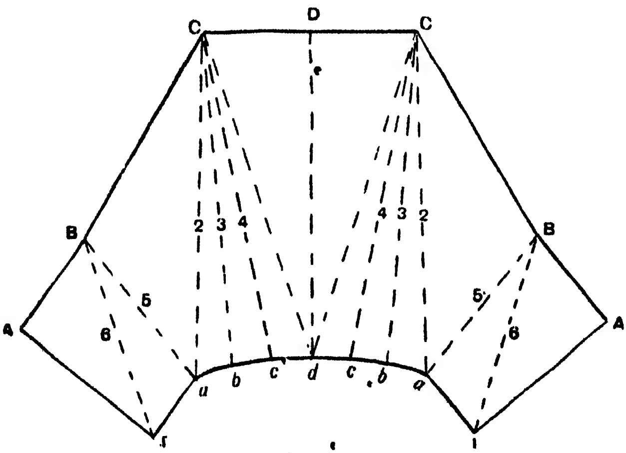


Fig. 164

Figs. 163 and 164.—Pattern for Chute.

diagonal $3'$ is shown united to b', therefore unite $3''$ to b'', and so on. To set out the pattern (Fig. 164), make D C equal to D C (Fig. 163), then make D d (Fig. 164) equal to D d (Fig. 163). Make $d\,c$ (Fig. 164) equal to 1 2 (Fig. 163), then transfer the true length of diagonal number 4 (shown in Fig. 163 as $c''\,4''$) in order to fix the point c (Fig. 164). Make $c\,b$ (Fig. 164) equal to $d\,c$ (Fig. 164), and from C (Fig. 164) set off diagonal number 3 (shown in Fig. 163 as $b''\,b''$) in order to fix the point b (Fig. 164). Similarly make $b\,a$ (Fig. 164) equal to $c\,b$ (Fig. 164), and from C (Fig. 164) set off diagonal number 2 (shown in Fig. 163 as $a''\,2''$) in order to fix the point a (Fig. 164). Make C B (Fig. 164) equal to C B (Fig. 163), then with a (Fig. 164) as centre, and radius equal to a'' $5''$ (Fig. 163), definitely fix the point B. Make B A and $a\,1$ (Fig. 164) equal to B A and $a\,1$ (Fig. 163). With B (Fig. 164) as centre, and $a''\,6''$ (Fig. 163) as radius, definitely fix the point 1 (Fig. 164). Finally, make 1 A (Fig. 164) equal to $a\,d'$ (Fig. 163). Unite C, B, A, 1, and a (Fig. 164) with straight lines, and draw a curved line passing through a, b, c, and d to complete the pattern.

Pattern for Hopper with Hole Out of Centre.—Let $g'\,a'$ D A (Fig. 165) represent a side elevation and A B C D a half-plan of the hopper for which a pattern is required. First divide the semicircle equally, as at a, b, c, d, e, f, and g, and from the points of division draw the dotted lines 1, 2, 3, 4, 5, 6, 7, and 8, as indicated. Before the pattern can be drawn, the true elevational lengths of these dotted plan lines must first be obtained. Therefore set off from a along the line A D (Fig. 165) the respective lengths of the dotted plan lines so as to obtain $1'$, $2'$, $3'$, $4'$, $5'$, $6'$, $7'$, and $8'$, which unite to a', as shown in the illustration. To draw the pattern (Fig. 166), draw A a and B B at right angles to each other, making the former equal to A a' (Fig. 165), and

AB (Fig. 166) equal to AB (Fig. 165). Make *a b* (Fig. 166) equal to *a b* (Fig. 165) and B*b* equal to *a*′2′ (Fig. 165). Similarly, make *b c* (Fig. 166) equal to *b c* (Fig. 165) and B*c* (Fig. 166) equal to *a*′3 (Fig. 165). Make *c d* (Fig. 166) equal *c d* (Fig. 165) and B*d* (Fig. 166) equal to *d*′4′ (Fig.

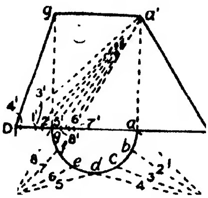


Fig. 165

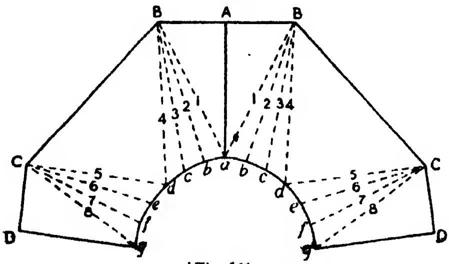


Fig. 166

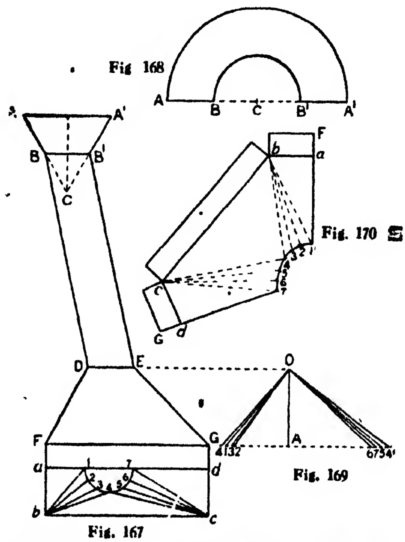
Figs. 165 and 166.—Pattern for Hopper with Hole Out of Centre.

165). Now set the compasses to BC (Fig. 165), and with B (Fig. 166) as centre, draw a small arc in the neighbourhood of C. Then with *d* (Fig. 166) as centre and the fifth dotted diagonal *a*′5′ (Fig. 165) as radius, cut this arc and thus obtain C (Fig. 166). Repeat this method of working until all the points are transferred to the pattern, after which

unite *g*, D, C, and B with straight lines, and *g* to *g* (Fig. 166), with a curved line passing through the points *f*, *e*, *d*, *c*, *b*, and *a*, to complete the pattern. It will be noted that the dotted diagonals of the pattern are simply the dotted elevational lines originally obtained from the dotted plan-lines in Fig. 165, and as their respective numbers are preserved from the first to the final stage, no difficulty should be experienced in thus tracing them.

Patterns for Hopper and Chute.—An elevation of a chute with mouthpiece and outlet is shown by Fig. 167. To obtain a pattern for the mouthpiece A A′ B B′ (Fig. 167), first obtain the apex C, as indicated, then with C (Fig. 168) as centre, and C B and C A (Fig. 168) as radii, describe arcs of circles. Make the larger arc equal to $3\frac{1}{7}$ times A A′ (Fig. 167), then join A B and A′B′ (Fig. 168) to give the pattern required. In this case the arcs are semicircular because the slant length of the cone is equal to the diameter. This is known in the trade as "funnel shape." Patterns will not be required for the round pipe. Instead of making a square pipe to fit on the rectangular outlet, it will be better to make a rectangular outlet having a round top, a pattern for which may be set out as follows: Let D E F G *a d* (Fig. 167) represent an elevation, and *a b c d* 1 4 7 a half-plan of the outlet. Divide the semicircle equally, and unite the points of division to the corners *b* and *c* as indicated. The true lengths of these plan lines must now be obtained before the pattern can be drawn. Therefore make A 1, A 2, A 3, A 4 (Fig. 169) equal to *b* 1, *b* 2, *b* 3 and *b* 4 (Fig. 167); similarly make A 4′, A 5, A 6, A 7 (Fig. 169) equal to *c* 4, *c* 5, *c* 6, and *c* 7 (Fig. 167), and join them to O (Fig. 169). Make *a* 1 and *a b* (Fig. 170) equal to D F and *a b* (Fig. 167) respectively. With *b* (Fig. 170) as centre, and radii equal respectively to O 1, O 2, O 3, and O 4 (Fig. 169), draw a series of small arcs,

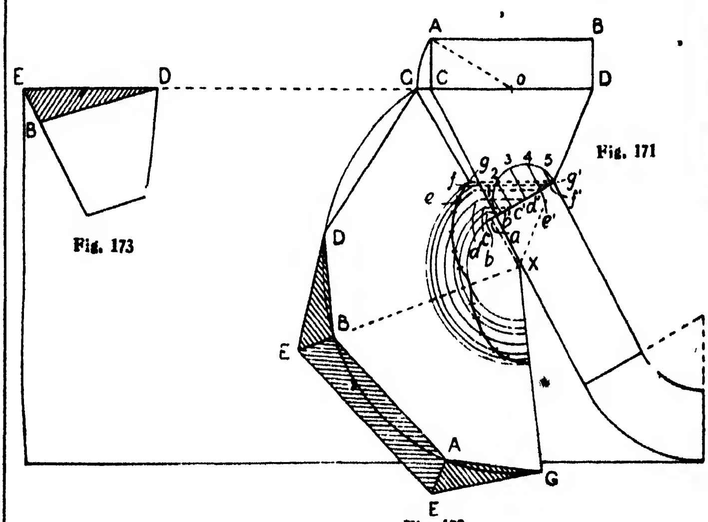
then with compasses set to one of the divisions of the semicircle in the half-plan (Fig. 167) cut these arcs in Fig. 170 (beginning at 1), and thus obtain the points 2, 3, and 4. With *b* (Fig. 170) as centre and *b c* (Fig. 167) as radius draw



Figs. 167 to 170.—Patterns for Hopper and Chute.

an arc. Then with 4 (Fig. 170) as centre, and o 4′ as radius, cut this arc and thus obtain *c* (Fig. 170). With this latter point as centre, and radii equal respectively to o 5, o 6, and o 7 (Fig. 167), draw another series of arcs. Then with the compasses step off the remaining points 5, 6, and 7. With *c* (Fig. 170) as centre, and *c d* (Fig. 167) as radius, draw an

arc; then with 7 (Fig. 170) as centre, and E G (Fig. 167) as radius, cut this arc to obtain *d*, which unite to 7. Unite also *b*, *c*, and *d* with straight lines. Make *a* F and G *d* equal to *a* F and G *d* (Fig. 167), and draw lines parallel with *a b*, *b c*, and *c d* (Fig. 170), as indicated. This completes one-half of the pattern for the rectangular outlet, and the other



Figs. 171 to 173.—Pattern for Hopper.

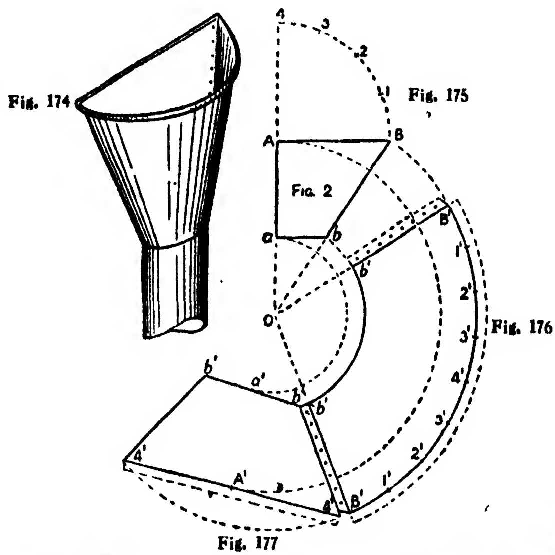
half is identical and may be obtained by repeating the method of working just explained.

Pattern for Hopper.—Let Fig. 171 represent a side elevation of the hopper, pipe, and bend. First describe a semicircle on the junction line, which divide equally as at 1, 2, 3, 4, and 5. Draw straight lines from these points, as indicated, in order to obtain b', c', d', e' and f' on the junc-

tion line, and then project dotted lines from these latter points to the side of the hopper so as to obtain *a*, *b*, *c*, *d*, *e*, *f*, and *g*. Now let ABCD (Fig. 171) represent a half-plan of the top of the hopper. With compasses set to A *o*, and with the latter point as centre, obtain G. Produce D *g′* (Fig. 171) to obtain X, then with this point as centre and G X as radius, describe the arc as illustrated in Fig. 172. Make G D (Fig. 172) equal to A B (Fig. 171), and make D B (Fig. 172) equal to twice B D (Fig. 171). Similarly make B A G (Fig. 172) equal to G D B (Fig. 172), and unite these points with straight lines. From X draw a series of arcs from *a*, *b*, *c*, *d*, *e*, *f*, and *g* on the side of the hopper. Then, setting the compasses to one of the divisions of the semicircle on the junction line, say 3 4 (Fig. 171), step off from *g* twelve divisions, passing from one arc to another, as indicated. The points are then joined up with a curved line. At this stage Fig 172 represents a pattern for the hopper as illustrated in Fig. 171, that is, with the taper in one direction only; but as the hopper is also desired to taper as in the front elevation (Fig. 173) the cross hatched part of Fig. 173 must be added to the pattern. Therefore make D B E and A G E (Fig. 172) each equal to D B E (Fig. 173). Unite D, E, E, and G to complete the pattern.

Patterns for Semicircular Chute.—The chute represented by Fig. 174 consists of three separate parts: the flat back, the semicircular front, and the outlet pipe. Two patterns only will be required—one for the front, and one for the back, the outlet pipe reqniring no pattern. First draw an elevation of the chute as at A B *a b* (Fig. 175). With A as centre draw the dotted quarter circle B 4, which divide equally as at 1, 2, and 3. Produce A *a* and B *b* to give the centre O, and from the latter point draw arcs from A, B, *a*, and *b* as indicated. Now from B′ to B′ (Fig. 176) step off

twice the number of distances that are contained in the dotted quarter-circle (Fig. 175), and unite B′ to O. This gives the pattern for the front, the lap edges for the riveted

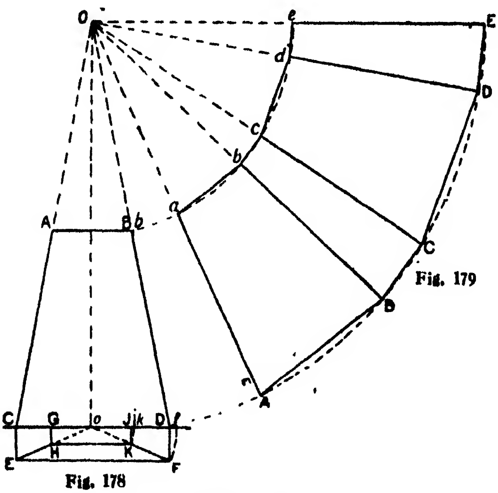


Figs. 174 to 177.—Patterns for Semicircular Chute.

seams and the wiring edge being afterwards added as illustrated. A pattern for the back is shown by Fig. 177, where A′4′ and $a'b'$ equal respectively A4 and ab (Fig. 175). Unite $b'b'$, 4′4′, and the sides $b'4'$ to complete the pattern. The dotted straight edge along 4′4′ represents the wiring edge. It may be mentioned that both the back and front of the chute may be made of one plate of metal if the dimensions allow of it, in which case no difficulty should be experienced in reconstructing the patterns to suit. Thus, supposing a joint pattern is required, with one riveted seam

at one of the corners, then the lap seam along B′ b' and b' 4′ would be eliminated, so that b' 4′ would then coincide with b' B. A suitable wiring edge is two and a half times the thickness of the wire, and in this case it would be 1 in.

Pattern for Hopper.—Let ABCD (Fig. 178) represent the elevation of a hopper, and CDEFGHJK a half-plan. Pro-



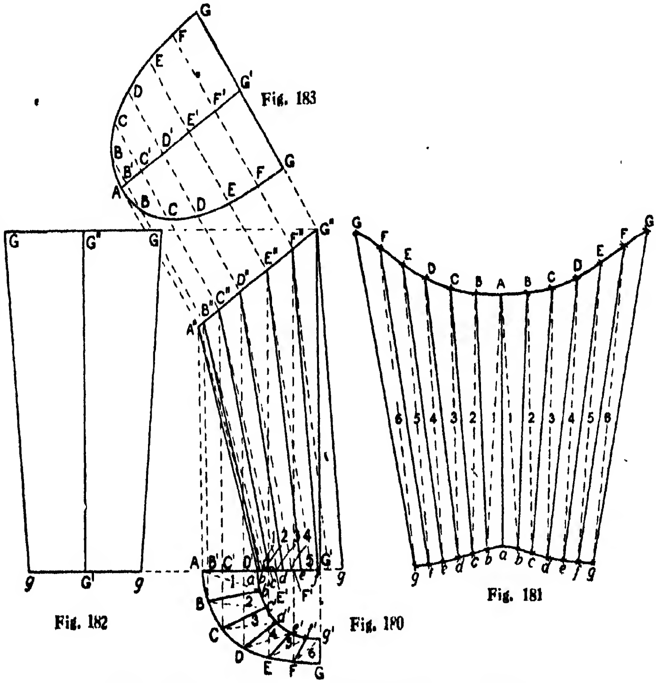
Figs. 178 and 179.—Pattern for Hopper.

duce AC and DB to obtain O. With o as centre, draw an arc from F to give f on the base line; similarly, draw one from K to give k on the base line, and erect a perpendicular to give b. With O as centre and radii O f and O b, draw the dotted arcs as in Fig. 179. Make AB (Fig. 179) equal to EF (Fig. 178); make BC (Fig. 179) equal to twice DF (Fig. 178), and repeat to obtain DE (Fig. 179). Similarly, make $a\,b$ (Fig. 179) equal to HK (Fig. 178), make $b\,c$ (Fig. 179) equal

to twice JK (Fig. 178) and repeat to obtain *de*. Unite the points thus obtained, as illustrated, to give ABCDE*abcde* (Fig. 179), the pattern required.

Patterns for Ship's Ash Chute.—Let A″ G″ *a* G′ (Fig. 180) represent an elevation, and A *a* G *g′* a half-plan of the chute. First divide the arcs A G and *ag′* equally as at BCDEF *b′ c′ d′ e′ f*. Join B *b′*, C *c′*, D *d′*, etc., with straight lines, then draw the dotted diagonals from 1 to 6, as illustrated. Before a pattern for the body can be set out, the true elevational lengths of all these plan lines must be obtained as follows: Unite A A″, B B″, C C″, D D″, etc., in order to obtain A, B′, C′, D′, etc., on the base line. From A set off A 1 on the base line, making it equal to A *b′*, then join A″ 1 with dotted lines to give the true length of the first diagonal. Similarly, set off from B, B′2, making it equal to B *c′*; join B″ 2 with dotted lines to give the true length of the second diagonal, as indicated. From C′, D′, E′, and F′, respectively, set off along the base line the plan lengths of the diagonals marked 3, 4, 5, and 6, then join by dotted lines to C″, D″, E″, and F″ to obtain their true lengths. The true lengths of the plan lines A *a*, B *b′*, C *c′*, D *d′*, E *e′*, F *f′*, and G *g′* are similarly obtained. A″ *a*, of course, is the true length of A *a*. To obtain the true length of B *b*, make B′ *b* on the base line equal to B *b′*, and unite B″ *b*, which then becomes the true length required. The plan lengths C *c′*, D *d′*, E *e′*, F *f′*, and G *g′* are represented on the base line by C′ *c*, D′ *d*, E′ *e*, F′ *f*, and G′ *g*; lines are drawn from C″, D″, E″, F″, and G″ to *c′*, *d*, *e*, *f*, and *g* respectively to give the remaining true lengths. A pattern for the body is shown in Fig. 181, where A *a* equals A″ *a* (Fig. 180). Make A B and *a b* (Fig. 181) equal respectively to A B and *a b′* (Fig. 180); with A (Fig. 181) as centre, and the dotted diagonal A″ 1 (Fig. 180) as radius, obtain points *b* in Fig. 181, then with this latter point

as centre and $B''b$ (Fig. 180) as radius, obtain points B. Repeat this method of working by transferring separately the various lengths from Fig. 180 to Fig. 181, and draw curves from G to G and g to g to complete the pattern. A



Figs. 180 to 183.—Patterns for Ship's Ash Chute.

pattern for the back is shown in Fig. 182, where $G''G$, $G'g$ equals $G'G$, $G'g'$ (Fig. 180), $G''G'$ (Fig. 182) being made equal to $G''G'$ (Fig. 180). If desirable, half of this pattern (Fig. 182) may be attached to each end of Fig. 181, in which case the seam would come down the centre of the back. A pattern for the lid is shown in Fig. 183, which

is almost self-explanatory. Lines are projected from A″, B″, C″, D″, E″, F″, and G″ (Fig. 180) to give A, B′, C′, D′, E′, F′, and G′ (Fig. 183). On each side of the central line make B′B, C′C, D′D, E′E, F′F, and G′G equal to B′B, C′C,

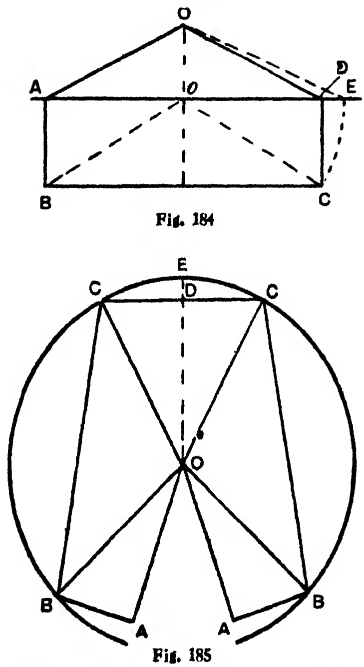


Fig. 184

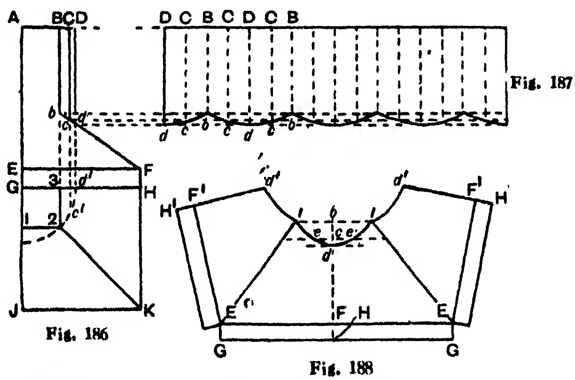
Fig. 185

Figs. 184 and 185.—Pattern for Tapering Rectangular Ventilator Top.

D′D, E′E, F′F, and G′G (Fig. 180), and draw a curve to pass through the points thus obtained to complete the pattern.

Pattern for Tapering Rectangular Ventilator Top.

—Let A O D (Fig. 184) represent an elevation, A B C D a half-plan, and O *o* the upright height of the ventilator top. With compasses set to *o* C, describe the arc C E and join E O. To draw the pattern (Fig. 185), with O as centre and O E (Fig. 184) as radius, describe a circle as indicated. Make C C (Fig. 185) equal to twice C D (Fig. 184), make B C (Fig. 185) equal to B C (Fig. 184), and make B A (Fig. 185) equal to C D (Fig. 185). Unite A B and C to obtain the pattern, which is



Figs. 186 to 188.—Patterns for Round Pipe on Square Pyramid.

thus marked at the corners for guidance in bending it to shape. The ventilator may be made in one, two, or four pieces (according to its size and the material of which it is to be made), but in any case allowance for seaming should be added to the pattern.

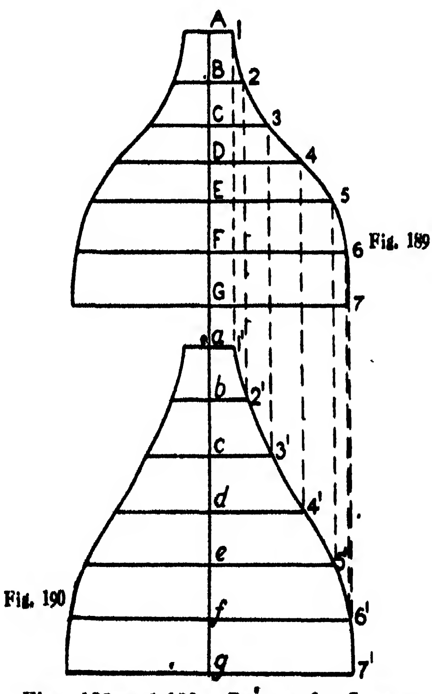
Patterns for Round Pipe on Square Pyramid.— First draw a quarter plan as at G H J K 1 2 3 *c' d'*, and a half elevation as at A E G D *d* F H (Fig. 186). The quarter circle represents one-quarter of the top of the round pipe,

and the quarter square 1 2 3 represents one-quarter of the top of the square base. Bisect $d'2$ to obtain c', and from these points draw vertical lines to obtain b, c, and d on the junction, and B, C, and D on the top of the pipe. To draw the pattern for the pipe, set the compasses to $d'c'$, and step off sixteen divisions as at D, C, B, etc., in Fig. 187. Project the dotted lines from $b\,c\,d$ (Fig. 186) to cut the vertical lines marked coincidently in Fig. 187, and through the points thus obtained draw the curves d, c, b, etc., as indicated. Fig. 188 represents a half pattern for the base. Let EF equal EF (Fig. 186), and make FH$d\,c\,b$ (Fig. 188) equal to those similarly marked in Fig. 186. Make $b\,1$ (Fig. 188) equal to 1 2 (Fig. 186), and with compasses set to $c'd'$ (Fig. 186), use d (Fig. 188) as centre, and obtain e. Draw a curve through 1 $e\,d\,c$ 1 to complete one-quarter of the pattern. The other points are similarly obtained; or the whole pattern may be marked from the quarter pattern if desired.

CHAPTER VII

Curved Tapering Bodies

Pattern for Square Moulded Ventilator Top.—Let Fig. 189 represent an elevation of the ventilator top for which a



Figs. 189 and 190.—Pattern for Square Moulded Ventilator Top.

pattern is required. First divide the curve equally as at 1, 2, 3, 4, 5, 6, and 7, and from these points draw lines at

right angles to the central line in order to obtain A, B, C, D, E, F, and G. Now along the central line *ag* (Fig. 190), make *a*, *b*, *c*, *d*, *e*, *f*, and *g* equal to 1, 2, 3, 4, 5, 6, and 7 (Fig. 189), and through these points draw parallel lines as indicated. Make $a1'$, $b2'$, $c3'$, $d4'$, $e5'$, $f6'$, and $g7'$ (Fig. 190) equal to those marked similarly in Fig. 189. This may be done by drawing lines from 1, 2, 3, 4, 5, 6, and 7 (Fig. 189) to 1′, 2′, 3′, 4′, 5′, 6′, and 7′ (Fig. 190) as shown. A curve is now drawn through the latter points to complete one-half of the pattern, and the other half of the pattern may be similarly obtained. Four pieces are required to make the ventilator, and these should be bent (together if possible) to the elevational curve from 1 to 7 (Fig. 189).

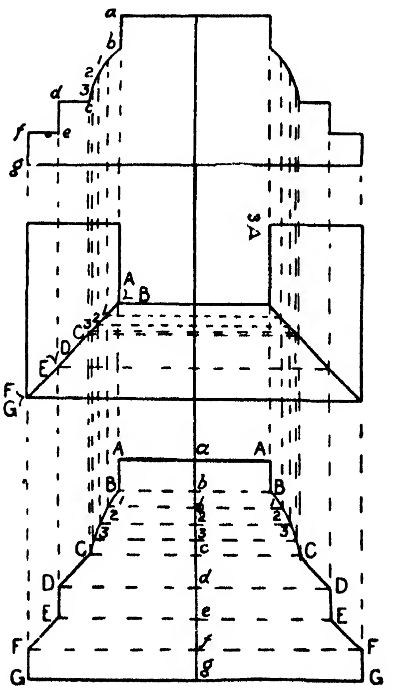
Pattern for Sheet-metal Moulding.—Only one pattern will be required, since the moulded base is square, and the sides consequently equal. Let Fig. 191 represent an elevation, and Fig. 192 a half-plan of the base under consideration. First fix a number of points, *a*, *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 191), and divide the arc *bc* equally as at 1, 2, and 3. The shape indicated by these points may be taken to represent a section of the moulding. A series of dotted lines is now drawn from these points (Fig. 191) in order to obtain A, B, 1, 2, 3, C, D, E, F and G on the junction line (Fig. 192). To draw the pattern (Fig. 193) set off along the central line the distances *a*, *b*, 1, 2, 3, *c*, *d*, *e*, *f*, and *g*, making them equal to the distances shown, and similarly marked, at the section (Fig. 191). A series of dotted parallel lines is now drawn through the points in Fig. 193, as indicated. The respective lengths of these lines are now required to be the same as those shown above in the half-plan (Fig. 192), but instead of transferring these lengths from Fig. 192 to Fig. 193, the same result can be obtained much quicker by projecting the series of dotted lines direct from

Fig. 191 to Fig. 193, thus giving A, B, 1, 2, 3, C, D, E, F, and G (Fig. 193). Repeat this method of procedure on the other side of the central line, and join up the points thus

Fig. 191

Fig. 192

Fig. 193



Figs. 191 to 193.—Pattern for Sheet-metal Moulding.

obtained, as illustrated, to complete the pattern. It is quite unnecessary in workshop practice to draw all the lines shown in the illustrations. These are drawn here simply to show where certain points first appear in the elevation, then in plan, and finally on the pattern, so that the principle involved may be readily understood.

Covering Square Turret with Sheet Copper.—First, let Fig. 194 represent an elevation of the turret. The ball is covered with two hemispheres of copper, the position of the joint depending on whether the ball can be removed or not. If it can be removed, the joint should preferably run

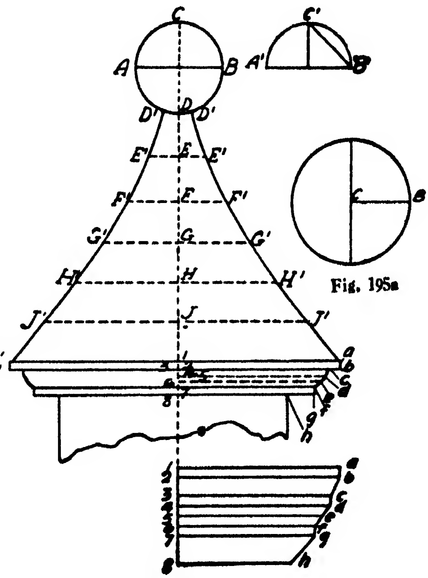


Fig. 194

Fig. 195a

Fig. 196

Figs. 194 to 196.—Covering Square Turret with Sheet Copper.

circumferentially round the ball as at A B, but if the ball is a fixture, then the joint will be as at C D, in which case both hemispheres will need scalloping at the base to allow them to fit together. To obtain the size of the discs to be hollowed, let A′ C′ B′ (Fig. 195) represent one-half of the ball. A line now drawn from C′ to B′ will give the radius required. A

pattern for the disc is shown by Fig. 195*a*, which further explains the method of working. The moulding for the turret should be made in four lengths—one for each side of the square, and a pattern for the mitred joints may be set out as follows: Divide the curve of the moulding *c f* equally as at *d* and *e*, and from these points draw lines to the central line. Now step off the distances from 1 to 8 (Fig.

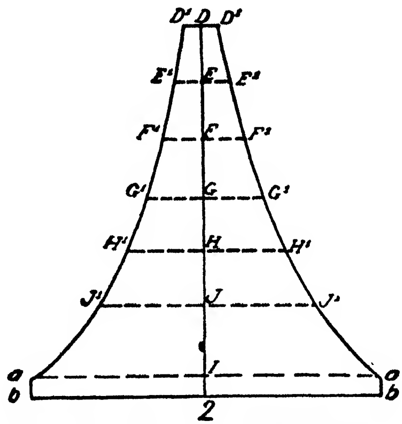


Fig. 197.—Pattern for Side of Square Turret.

196), making them equal to the distances *a*, *b*, *c*, *d*, *e*, *f*, *g*, and *h* (Fig. 194). From these points (Fig. 196) draw lines at right angles to the line 1 8, and transfer respectively the lengths of the lines from Fig. 194 to Fig. 196. Thus 1 *a* (Fig. 194) equals 1 *a* (Fig. 196), similarly 2 *b* (Fig. 194) equals 2 *b* (Fig. 196) and so on, after which unite the points from *a* to *h* as indicated to give the pattern (Fig. 196). Care should be taken to bend the mouldings properly and true to shape,

otherwise the mitred joints cannot be expected to fit exactly. A pattern for the four tapering sides is shown at Fig. 197, which may be obtained as follows: First divide

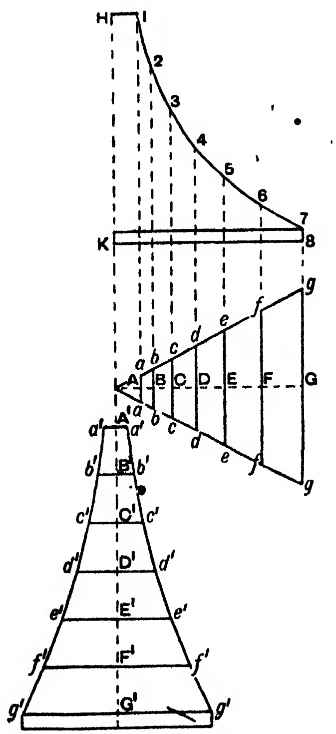


Fig. 198.—Pattern for Hexagonal Tapering Body.

the elevational curve D′ *a* (Fig. 194) equally, as at E′, F′, G′, H′, I′, and from these points draw a series of horizontal lines, as indicated, in order to obtain the points on the central line of Fig. 194. Now set off along the straight

central line D, 2 (Fig. 197), the distances E, F, G, H, J, 1, 2, making them equal to the distances D′, E′, F′, G′, H′, J′, *a*, *b*, on the elevational curve of Fig. 194. A series of dotted lines are drawn through these points, and at right angles to the central line, after which the distances D′D′, E′E′, F′F′, G′G′, H′H′, J′J′, *a*′*a*, *b*′*b* (Fig. 197), are made equal to those marked similarly in Fig. 194. A curve drawn from D′ to *b*, on either side of the central line (Fig. 197), completes the pattern.

Pattern for Hexagonal Tapering Body.—Let H 1 K 8 (Fig. 198) represent a half elevation, and *a a g g* one of the segments in plan. Divide the elevational curve 1 7 into a number of equal parts, and from the points of division draw dotted lines to give the lines *a* A *a*, *b* B *b*, *c* C *c*, etc., on the plan. To draw the pattern, along the line A′G′ set off B′, C′, D′, etc., making them equal to the distances 1, 2, 3, etc., on the elevational curve. Make the lines *a*′*a*′, *b*′*b*′, *c*′*c*′, etc., equal respectively to those marked coincidently on the plan, and draw a curved line on each side of the central line from *a*′ to *g*′, to complete the pattern. An octagonal pattern may be set out similarly by substituting, of course, the plan of the octagonal segment for the hexagonal.

Pattern for Finial Base.—Let A K F D (Fig. 199) represent an elevation, and F *f*′ G H J D a half-plan of the base of the finial. First divide the elevational curve A F (Fig. 199) into a number of equal parts as at B, C, D, and E, and from these points draw vertical lines to the half-plan, in order, to obtain the points *a a*′, *b b*′, *c c*′, *d d*′, *e e*′, and F *f*′. To draw the pattern (Fig. 200), along a straight line *a f* step off the distances *b*, *c*, *d*, and *e*, making them equal to A, B, C, D, E, and F (Fig. 199), and through the points thus obtained draw lines at right angles to the original line.

Now transfer the distances *a a′*, *b b′*, *c c′*, *d d′*, *e e′*, and F *f′* from Fig. 199 to Fig. 200, as indicated, and draw curves to pass through the points to complete the pattern. As this base is octagonal, eight pieces, each equal to the pattern, will be required. A square or hexagonal base may be set out similarly.

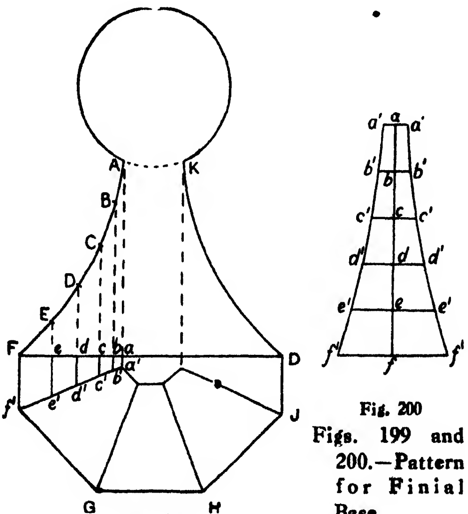


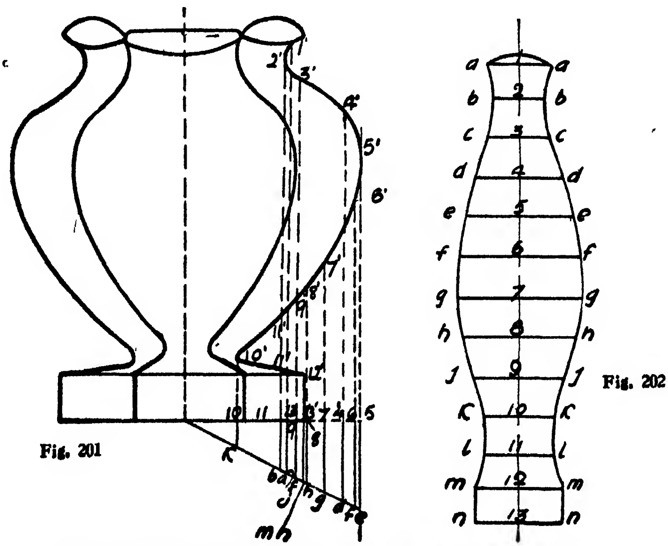
Fig. 199

Fig. 200

Figs. 199 and 200.—Pattern for Finial Base.

Pattern for Octagonal Fern-pot.—A very useful and effective table decoration is represented by the fern-pot as shown in Fig. 201. To obtain a pattern for the body, first divide the elevational curve into a number of equal parts, as at 1′, 2′, 3′, 4′, etc., to 13′ (Fig. 201). A series of dotted lines are now drawn from these points, and parallel with the central line, as indicated, in order to give the points from 1 to 13 on the base line, and also

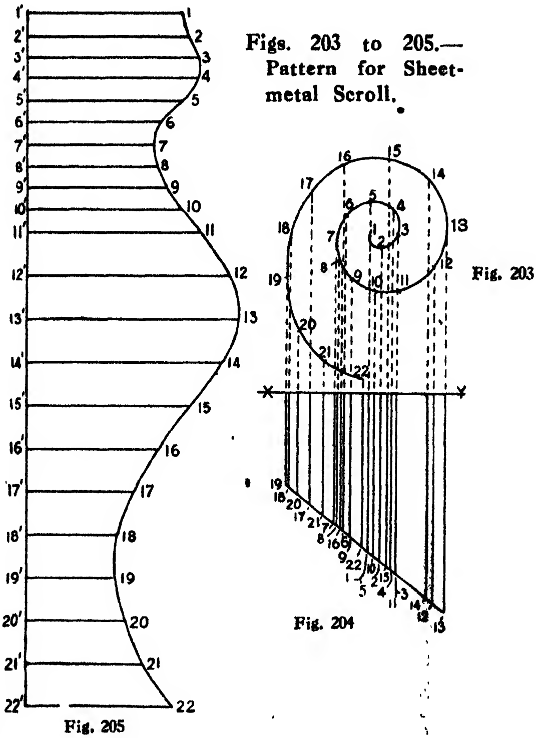
the points *a*, *b*, *c*, etc., to *n*, on the junction line of the half segment shown in plan. Now along the dotted central line of Fig. 202 step off the distances 1, 2, 3, etc., to 13, making them equal to those distances 1′, 2′, 3′, etc., to 13′ on the elevational curve of Fig. 201. A series of short



Figs. 201 and 202.—Patterns for Octagonal Fern-pot.

straight lines are drawn through these points, as illustrated in Fig. 202, after which the plan lengths *a* 1, *b* 2, *c* 3, *d* 4, *e* 5, *f* 6, etc., are transferred from Fig. 201 to Fig. 202. Thus 5 *e*, on either side of the central line (Fig. 202), is made equal to 5 *e* below the base line (Fig. 201). Similarly, 6 *f* and 4 *d* (Fig. 202) are made equal to 6 *f* and 4 *d* (Fig. 201), and so on. When all the distances and

lengths have been transferred, a curve is drawn on either side of the central line from *a* to *n* (Fig. 202), passing through the points *b*, *c*, *d*, *e*, etc., to complete the pattern.



Figs. 203 to 205.—Pattern for Sheet-metal Scroll.

Eight pieces cut to this shape will constitute the body of the pot, and all the pieces, of course, must be bent to the shape of the elevational curve in Fig. 201.

Pattern for Sheet-metal Scroll.—Let Fig. 203 represent an end elevation, and Fig. 204 a half-plan of the

scroll. Divide the elevational curve (Fig. 203) as indicated from 1 to 22. It will be noted that in order to gain greater accuracy the curve is divided from 1 to 11 into smaller divisions than those from 11 upwards. Projectors are now drawn from the points of division to the base line XY, and from thence to the half-plan in order to fix the points from 1 to 22 on the half-plan. To draw the pattern, along a straight line (Fig. 205) set off the distances 1′ to 22′, making them equal to the respective distances on the curve (Fig. 203). Lines are now drawn from the points of division at right angles to the line 1′22′ (Fig. 205). The plan distances from the base line XY are now transferred to those marked coincidently in Fig. 205. Thus the lines 1′1, 2′2, 3′3, 4′4, etc. (Fig. 205), are equal to those marked 1, 2, 3, 4, etc., on the half-plan (Fig. 204). When all the distances have been transferred from Fig. 204 to Fig. 205, a curved line is drawn as indicated from 1 to 22 (Fig. 205), to complete the pattern. The other mitres may be marked off by using the same pattern; and care should be taken when shaping the scrolls to follow the lines of the elevational curve given in Fig. 203, from which the pattern has been obtained.

CHAPTER VIII

Irregular Bodies

Pattern for Body Tapering Obliquely from Oval to Round.—Let A G $a\,g$ (Fig. 206) represent an elevation, and $a\,3'\,G'\,g\,d$ a half-plan of the body for which a pattern is required. First divide the semicircle $a\,3'\,G'$ and the semi-ellipse $a\,d\,g$ equally, then join the points as illustrated. Before the pattern can be drawn, the true elevational lengths of all the plan lines must be obtained; this may be done as follows: Make $G'b'$ (Fig. 206) equal to $1'b$, $G'c'$ equal to $2'c$, $G'd'$, $G'e'$ and $G'f'$ equal respectively to $3'd$, $4'e$, and $5'f$. Then unite $b'\,c'\,d'\,e'$ and f' to G (Fig. 206). $G\,f'$ will then represent the true elevational length of the plan line $5'f$; $G\,e'$ will be the true length of $4'e$, and so on. Now obtain the true elevational lengths of the dotted diagonals (shown in plan as 1, 2, 3, 4, 5 and 6) by making $o\,6$ (Fig. 207) equal to the length of the dotted diagonal marked 6 in Fig. 206. Similarly make $o\,5$, $o\,4$, $o\,3$, $o\,2$ and $o\,1$ (Fig. 207) equal respectively to the lengths of the dotted diagonals 5, 4, 3, 2 and 1 (Fig. 206), then join 1, 2, 3, 4, 5 and 6 to O (Fig. 207). O 6 (Fig. 207) is the true elevational length of the dotted diagonal marked 6 in plan (Fig. 206), and so on as regards the others. The body is to be made of two pieces, and the seams are required at a and $G'g$ (Fig. 206), therefore a pattern for one-half of the body will suffice, since both halves are identical. To draw the pattern (Fig. 208) make $G\,g$ equal to $G\,g$ (Fig. 206); make $G\,5'$ and $g\,f$ (Fig. 208) equal to $G'5'$ and $g\,f$

(Fig. 206); make G*f* (Fig. 208) equal to o6 (Fig. 207); make *f*5′ (Fig. 208) equal to G*f*′. Make 5′4′ and *fe* (Fig.

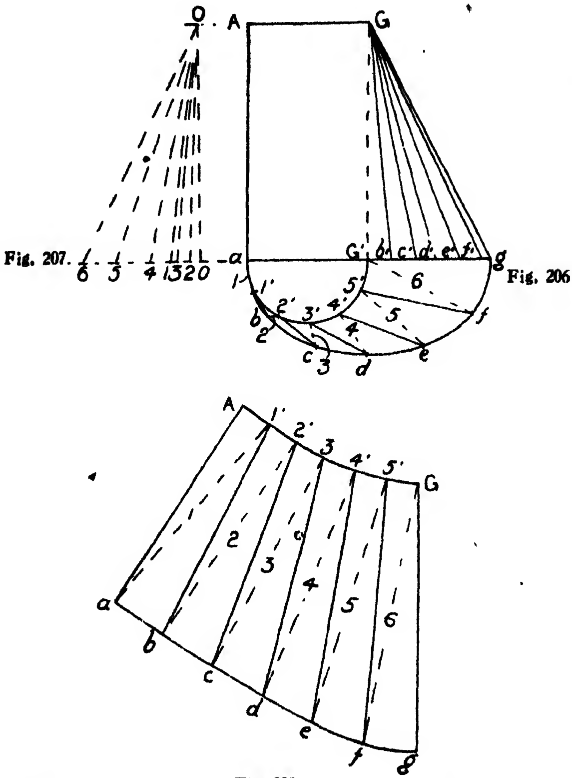


Fig. 208

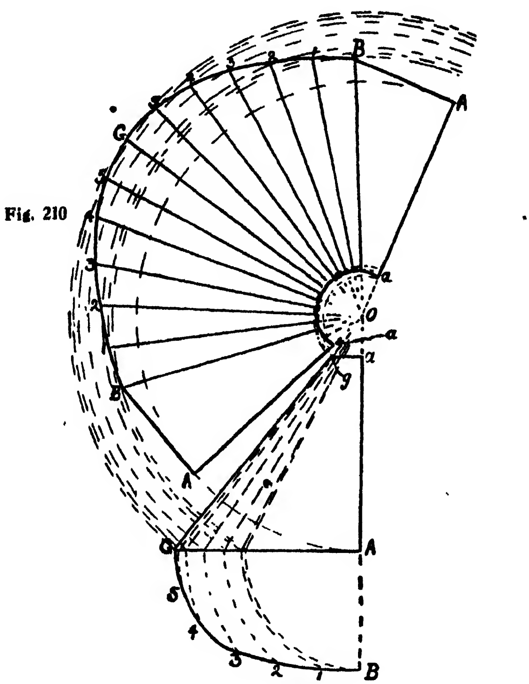
Figs. 206 to 208.—Pattern for Body Tapering Obliquely from Oval to Round

208) equal to 5′4′ and *fe*. Make 5′*e* (Fig. 208) equal to o5 (Fig. 207), and *e*4′ equal to G*e*. Make 4′3′ and *ed* (Fig. 208) equal to 4′3′ and *ed*; make 4′*d* (Fig. 208) equal

to O 4 (Fig. 207), and $d3'$ equal to G d' (Fig. 206). Make $3'2'$ and dc equal to $3'2'$ and dc (Fig. 206); make $3'c$ (Fig. 208) equal to O 3, and $c2'$ equal to G c' (Fig. 206). Make $2'1'$ and cb equal to $2'1'$ and cb (Fig. 206); make $2'b$ (Fig. 208) equal to O 2, and $b1'$ equal to G b' (Fig. 206). Make $1'$A and ba (Fig. 208) equal to $1'a$ and ba (Fig. 206); make $1'a$ (Fig. 208) equal to O 1 (Fig. 207) and aA (Fig. 208) equal to aA (Fig. 206). A line drawn from A to G (Fig. 208) and another from a to g, through the points thus obtained, as illustrated, completes the half-pattern required. This method of obtaining the pattern by triangulation is really not so difficult as it might at first appear; and as the lines in all the figures are marked coincidently, as far as possible, a little careful study should render the method of working abundantly clear.

Pattern for Straight-sided Tundish.—Let ga G A (Fig. 209) represent a side elevation and G A B a half-plan of the tundish for which a pattern is required. First divide the arc G B equally, as at 1, 2, 3, 4, and 5, then with A as centre, draw a series of dotted arcs from the latter points to the base line, and from thence to the centre O. With O as centre, draw a series of dotted arcs from all the points on the base line as indicated in Fig. 210. Set the compasses to A B (Fig. 209), then, starting at A (Fig. 210), make the point B on the next dotted arc. With compasses set to B 1 (Fig. 209), and with B (Fig. 210) as centre, obtain 1 on the next dotted arc; then step off the distances 2, 3, 4, 5, and G, proceeding from arc to arc, as illustrated. Radial lines are now drawn from these points on the dotted arcs to the centre O, in order to obtain division points on the spout end of the pattern. A series of dotted arcs is now drawn from all the points on the top line ga (Fig. 209), and a curved line is drawn from a to a (Fig. 210), passing

from one arc to another in the space of one division. Join A B (Fig. 210) with a straight line, then draw a curved line from B to G (Fig. 210), passing from one arc to another

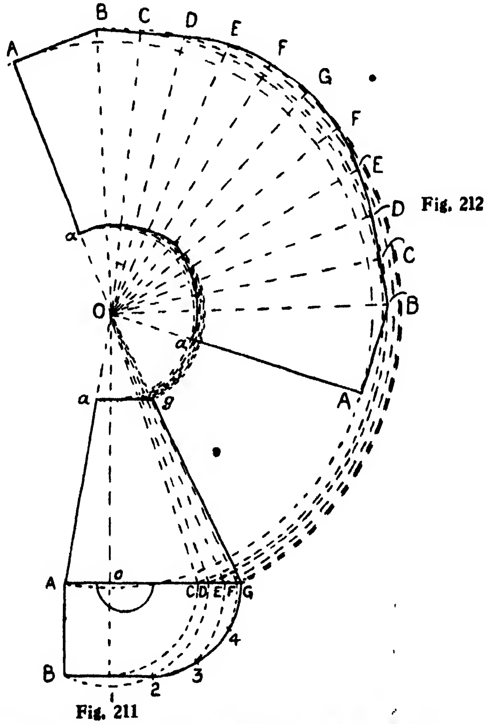


Figs. 209 and 210.—Pattern for Straight-sided Tundish.

in the space of one division. This completes one half of the pattern, and the other half may be obtained similarly. Fig. 210 shows the complete pattern, and it also illustrates the method of procedure. The seam will be situated in

the middle of the straight side, and if grooving edges are required these must be added along the lines A and *a* (Fig. 210).

Pattern for Irregular Funnel.—Let A G *a g* (Fig. 211)



Figs. 211 and 212.—Pattern for Irregular Funnel.

represent an elevation, and A B 1 2 3 4 G a half-plan of the irregular funnel for which a pattern is required. First, divide the outer curve of the half-plan equally as at B 1 2 3 4 G, then, with *o* as centre, draw a dotted arc from

each of these points in order to obtain C, D, E, and F, as indicated. Produce A*a* and G*g* to give the apex O, and unite C, D, E, and F to O with dotted lines. It will be observed that the dotted arc drawn from B coincides with the dotted arc drawn from 2, to give the point D. Therefore the latter point will be utilised later to obtain B and D on the pattern. To draw the pattern (Fig. 212), with O as centre, draw a series of dotted arcs from A, C, D, E, F, and G, and from *a* to *g* (Fig. 211) as illustrated. Then from A (Fig. 212) step off B, C, D, E, F, and G, making them equal to B, 1, 2, 3, 4, and G (Fig. 211), taking care to cross from one arc to another in the order shown. Thus D (Fig. 212) rests on the arc which is drawn from D (Fig. 211); similarly E (Fig. 212) is a point on the arc which is drawn from E (Fig. 211), and so on. Now draw the dotted radial lines to O (Fig. 212), and join up A, B, C, D, E, F, and G (Fig. 212) as illustrated. A similar curve passing from arc to arc is now drawn from *a* to *a* (Fig. 212) to complete the pattern.

Pattern for Body having Oblong Base with Rounded Corners and Circular Top.—If a pattern for a body having an oblong base with quadrant or rounded corners and a circular top is required, first draw a half-plan ABCDEF (Fig. 213). Divide the arcs GH (G and H being the points at which the round corners of the oblong base join the "straight") and EF in order to obtain the points J and K, and join EB, EH, JK, and FG. Join EJ and GK as shown by the dotted diagonals. Make the upright OL equal to the upright height of the body required; on the line XX to the left of O, set off OM and ON equal respectively to GK and EJ, and join to L with dotted lines, and to the right of O set off OP, OR, and OS each equal respectively to BE, CF, and FG, and join P, R, and S to L. The dotted lines LM and LN represent the true lengths of the

dotted diagonals of the plan, and the other lines LP, LR, and LS represent the true slant lengths of the lines CF, FG, JK, HE, and BE, shown in plan. In order to draw the pattern (Fig. 214), make B′E′ a straight line equal to

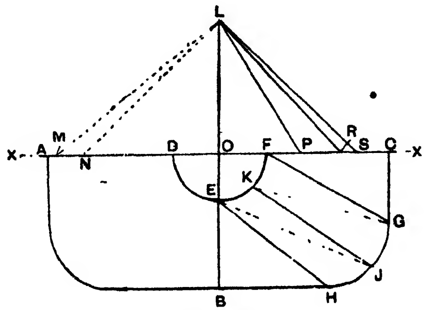


Fig. 213

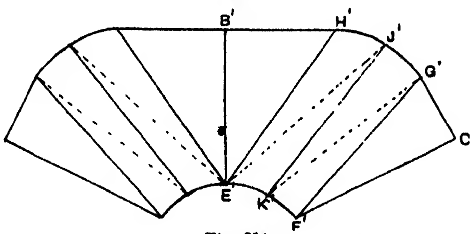


Fig. 214

Figs. 213 and 214.—Pattern for Body having Oblong Base with Rounded Corners and Circular Top.

LP in Fig. 213; draw a line at right angles to B′E′ (Fig. 214), and on each side of B′ make B′H′ equal to BH in Fig. 213. With H′ as centre and HJ (Fig. 213) as radius, draw an arc; with E′ (Fig. 214) as centre and radius equal to EK (Fig. 213), draw another arc; with the same centre and LM (Fig. 213) as radius, draw an arc that will cut in

the point J′ the arc that was previously drawn; and with J′ as centre and LS (Fig. 213) as radius, obtain the point K′ (Fig. 214). With J′ (Fig. 214) as centre and GJ (Fig. 213) as radius, draw an arc; with K′ as centre and FK (Fig. 213) as radius, draw another arc; with the same

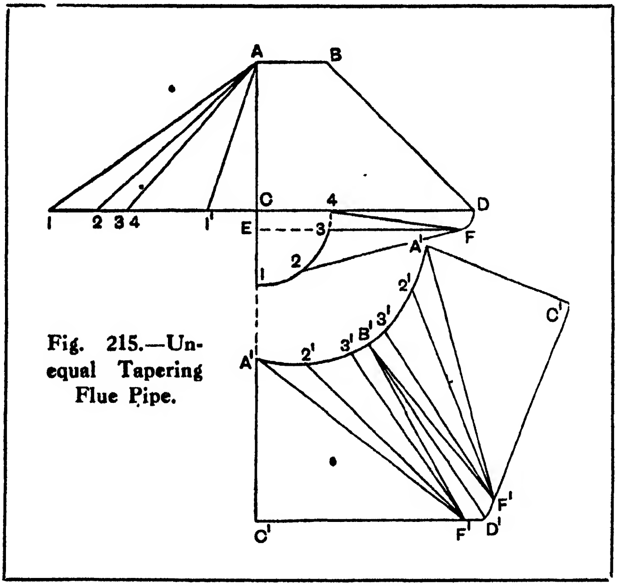


Fig. 215.—Unequal Tapering Flue Pipe.

centre and LN (Fig. 213) as radius, obtain the point G′ (Fig. 214). With G′ as centre and LS (Fig. 213) as radius, obtain the point F′ (Fig. 214). With G′ (Fig. 214) as centre and GC as radius, draw an arc, and with F′ (Fig. 214) as centre and a radius equal to LR obtain C′ (Fig. 214). Join C′F′, and draw the lines F′K′E′ and C′G′J′H′ through the points obtained, which will then give one-half of the body pattern, with seams at AD and CF. The other half of the pattern can be obtained in exactly the same way.

Unequal Tapering Flue Pipe.—Let ABCD (Fig. 215)

represent a half elevation, and C13FD a quarter plan. Bisect the arc 13 in the point 2, and draw lines from F as indicated. From C make 1^2, 2^2, 3^2, 4^2, equal respectively F1, F2, F3, F4; make C1′ equal to E1, and join these points to A with straight lines. To draw the pattern, make A′C′ equal to A1′, C′F′ equal to EF, and A′F′ equal to 1′. Now make A′2′ equal to 12; F′2′ and F′3′ equal respectively 2^2 and 3^2; make 2′3′ equal to 23, and 3′B′ equal to 34. Make F′B′ equal to 4^2 (which is coincident with 3^2), make F′D′ equal to FD, and make B′D′ equal to BD. This gives A′B′C′D′ (one-quarter of the pattern), and the illustration becoming now self-explanatory, shows A′C′D′C′A′ a half pattern, from which the other half can be marked off.

Pattern for Unequal Tapering Body.—Let A′G′AG (Fig. 216) represent a side elevation, and ABCDEFG*gfedc* a half-plan of the unequal tapering body for which a pattern is required. First divide the arc FC (Fig. 216) equally as at D and E. Similarly divide the arc *fc* (Fig. 216) equally as at *d* and *e*. Unite F*f*, E*e*, and D*d* with straight lines, then draw dotted diagonal lines from *f* to E, *e* to D, and *d* to C, as illustrated. Before the pattern can be drawn, the true elevational lengths of these plan lines must first be obtained, as follows: On the base line (Fig. 217) make OD equal to D*d* (Fig. 216). Make OE (Fig. 217) equal to E*e* (Fig. 216), then join D and E (Fig. 217) to *o* the top of the vertical line, which, it will be noted, is equal to the upright height of the body (Fig. 216). On the left side of O (Fig. 217) set off O1, equal to the dotted diagonal number 1 in the plan (Fig. 216). Similarly, make O2 and O3 (which happen in this case to coincide) equal respectively to the dotted diagonals 2 and 3 in the plan (Fig. 216). Then join 1, 2, and 3 (Fig. 217) to *o* with dotted lines, as illustrated. The lines thus obtained represent the true elevational lengths of the

lines shown in plan. To draw the pattern (Fig. 218), which represents a pattern for one-half of the body (that being sufficient as the other half is identical), make G′ G (Fig. 218) equal to G′ G. Make G′ *f* and G F (Fig. 218) equal to *g f* and G F respectively. With *f* (Fig. 218) as centre and *f e* (Fig. 216) as radius, draw an arc in the neighbourhood of *e*. Similarly, with F (Fig. 218) as centre, and F E (Fig. 216) as

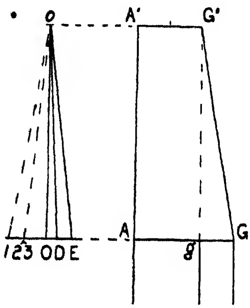


Fig. 217

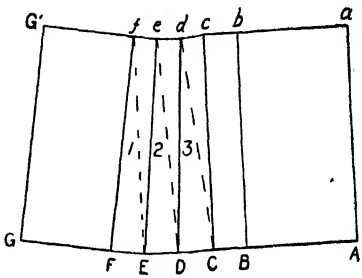


Fig. 218

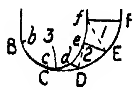


Fig. 216

Figs. 216 to 218.—Pattern for Unequal Tapering Body.

radius, draw an arc in the neighbourhood of E. With compasses set to *o* 1 (Fig. 217), and with *f* as centre, definitely fix the point E (Fig. 218). Then with this latter point as centre, and compasses set to *o* E (Fig. 217), likewise fix the point *e* (Fig. 218). Repeat this method of working to obtain the other points by making *e d* (Fig. 218) equal to *e d* (Fig. 216); E D (Fig. 218) equal to E D (Fig. 216); *e* D (Fig. 218) equal to *o* 2 (Fig. 217); and D *d* (Fig. 218) equal to *o* D (Fig. 217). This definitely fixes the points D and *d* (Fig. 218);

C and $\acute{c}$ (Fig. 218) may be obtained by making *d c* and D D equal respectively to *d c* and D *c* (Fig. 216). Then make *d* C and C *c* equal respectively to *o* 3 (Fig. 217) and A′ A (Fig. 216). Make *c a* and C A (Fig. 218) square to *c* C and set off *c b a* and C B A, making them equal to C B A (Fig. 216). Join *a* A (Fig. 218) with a straight line, and draw curves passing through the points *f*, *e*, *d* and *c*, and F, E, D, and C as indicated. G′ *a*, G A (Fig. 218) then represents a pattern for one-half of the body. The other half may be obtained similarly, or it may be marked off Fig. 218.

Pattern for Irregularly Shaped Pipe.—This is an exceptional example of unequal tapering bodies. On referring to Fig. 219, where A′ G′ A G represents an elevation of the body, and A B D *f* G a half-plan, it will be seen that the taper of that part represented in plan from A to D runs in an opposite direction to that part represented in plan by D *f* G, while the elevational line G′ G does not taper at all; and if this is borne in mind when setting out the pattern, much advantage will be gained. First divide the arc A D and the line *a d* (Fig. 219) into equal parts, and unite the points with the lines B *b*, C *c*, and the dotted diagonals 1, 2, and 3. Similarly divide the arc D *f g* and the arc *d* F G into equal parts, and unite the points thus obtained with the lines *e* E, *f* F, and the dotted diagonals 4, 5, and 6. The true lengths of these lines and diagonals are found by setting off from D′ their respective plan lengths, and then joining them to O. Thus O 1 equals the true length of the dotted diagonal marked 1 on the plan, O B′ is the true length of the plan line B *b*, while the elevational line A′ A is the true length of the plan line A *a*, and so on. To draw the pattern Fig. 220, make A *a* equal to A′ A (Fig. 219). With A (Fig. 220) as centre, and radius equal to A B (Fig. 219), describe an arc. With *a* (Fig. 220) as centre, and radius equal to *a b* (Fig.

219), describe another. With A (Fig. 220) as centre, and radius equal to O 1 (Fig. 219), cut the arc previously made to give the point *b* (Fig. 220); and from this point as centre,

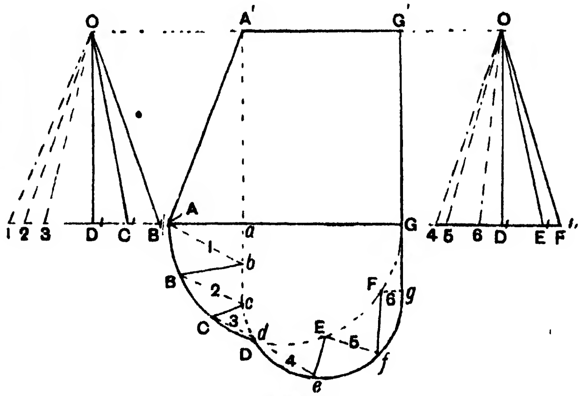


Fig. 219

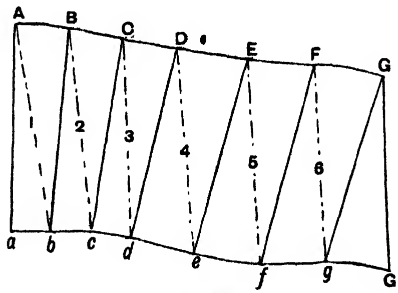


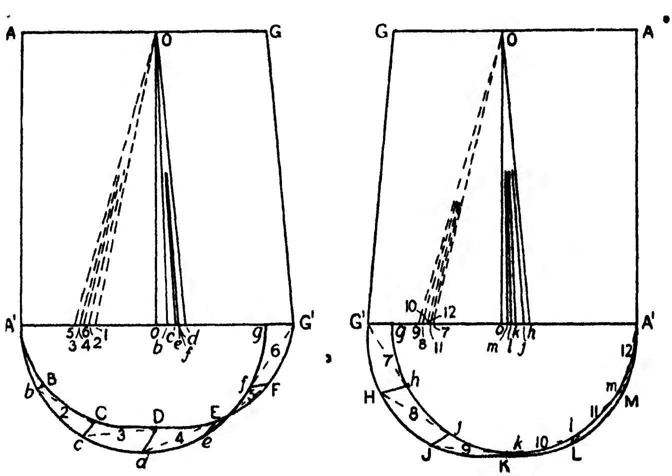
Fig. 220

Figs. 219 and 220.—Pattern for Irregularly Shaped Pipe.

and radius equal to O B′ (Fig. 219), cut the former arc to give the point B (Fig. 220). Repeat this method of working to obtain the other points. These points are then joined to-

gether as shown in Fig. 220, which represents a half pattern, whose seams correspond with the lines A′A and G′G (Fig. 219). The letter references of the plan coincide with those of the pattern, and little difficulty should be experienced in tracing them.

Pattern for Irregular Pipe.—Let Figs. 221 and 222 represent front and back elevations and half-plans of the



Figs. 221 and 222.—Pattern for Irregular Pipe.

pipe for which a pattern is required. It will be noted that the pipe tapers slightly and unequally from an oblong base having semicircular ends to a circular top. To obtain accuracy, careful working is necessary, as the crossing of the plan lines in Fig. 221 is apt to cause confusion. First divide the semicircle A′*dg* (Fig. 221) and the semi-oblong A′D G′ equally, as indicated, and join them together, as at

B b, C c, D d, E e, and F f. Now draw a series of dotted diagonals as from b to C, c to D, d to E, e to F, and f to G′. Before

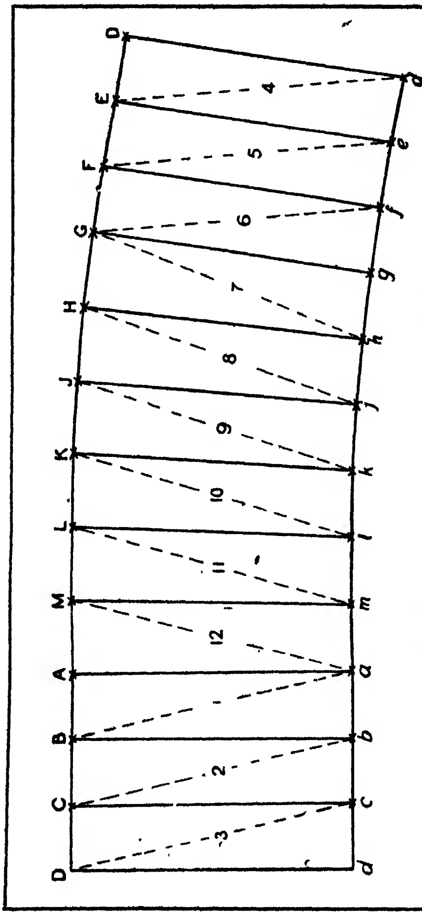


Fig. 223.—Pattern for Irregular Pipe.

the pattern can be set out, the true elevational lengths of these plan lines must first be ascertained, which may be done as follows: On the left side of O o (Fig. 221) set off

along, the base line A′G′ the respective lengths of the diagonals, making *o* 1 equal to A′*b*, *o* 2 equal to the length of the dotted diagonal marked 2, *o* 3 equal to diagonal 3, *o* 4 (which happens to coincide with *o* 3) equal to the fourth diagonal, *o* 5 equal to the fifth, and *o* 6 equal to the sixth, then unite these to the top of the central line O (Fig. 221). Similarly on the right side of the central line O *o* (Fig. 221) set off along the base line from *o* the distances *b*, *c*, *d*, *e*, and *f*, making them respectively equal to B *b*, C *c*, D *d*, E *e*, F *f*. Thus *o b* equals B *b*, *o c* equals C *c*, and so on. Join these to O as indicated; then on the right of the central line O *o* is obtained the true elevational lengths of the full lines shown in plan, while on the left are obtained those of the six dotted diagonals, also shown in plan. To set out the pattern (Fig. 223), first determine where the seam is to be placed, then begin with that line first. In the present example the seam is desired, at D *d*, on the half-plan of Fig. 221. Therefore make D *d* (Fig. 223) equal to O *d* (Fig. 221). Make D C and *d c* (Fig. 223) equal to D C and *d c* (Fig. 221); then with the compasses set to O 3 (Fig. 221), and with D (Fig. 223) as centre, obtain the point *c* (Fig. 223). With the later point as centre and the compasses set to O *c* (Fig. 221) obtain the point C (Fig. 223). Unite the points thus obtained, which gives that part of the pattern marked D C *d c* (Fig. 223). The remaining parts of the pattern are built up similarly; and it will therefore be unnecessary to deal with all of them individually. However, the pattern is practically self-explanatory, and should make the method of working abundantly clear. The chief point to be observed is the proper transference of all respective lines and distances from Figs. 221 and 222 to Fig. 223.

Pattern for Bunker Ventilator.—Let Fig. 224 represent an elevation and plan of the unequal tapering ventilator,

for which a pattern is required. First, divide the semicircles A J C and *a j c*, equally as at K B and *k b* respectively, and join J *j*, K *k*, A *a*, B *b*, and C *c* with full lines, and J *k*, K *a*, A *b*, and B *c* with dotted lines. Similarly, divide and join the points of division of the semicircles H F D and *h f d*,

Fig. 224

Fig. 225

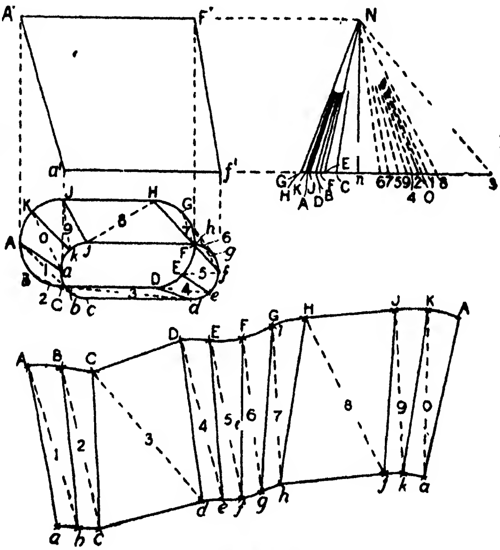


Fig. 226

Figs. 224 to 226.—Pattern for Bunker Ventilator.

taking care to avoid confusion where the large end crosses the small end. The true lengths of these plan lines must now be obtained before the pattern can be set out, therefore set off along the base line from *n* (Fig. 225) *n* A equal to A *a* (Fig. 224), *n* B equal to B *b* (Fig. 224), *n* C equal to C *c* (Fig. 224), *n* D equal to D *d* (Fig. 224), and so on up to K *k*, (Fig. 224), and join them to N (Fig. 225). To the right of *n*

(Fig. 225) set off along the base line the respective lengths of the dotted diagonals 1, 2, 3, 4, 5, etc. (Fig. 224), and join them to N (Fig. 225). The true elevational lengths of all the plan lines are thus shown properly lettered and numbered to coincide with those shown in Fig. 224. To draw the pattern (Fig. 226) begin with that line which corresponds with the seam. Thus supposing the seam is required at A *a* (Fig. 224), then the true length of A *a* (Fig. 224) is shown at N A (Fig. 225), which length is therefore transferred to A *a* (Fig. 226). Then with A (Fig. 226) as centre and A B (Fig. 224) as radius, describe an arc; similarly, with *a* (Fig. 226) as centre, and *a b* (Fig. 224) as radius, describe another. With A (Fig. 226) as centre, and N 1 (Fig. 225) as radius, cut the latter arc to obtain the point *b* (Fig. 226); with the latter point as centre and radius equal to N B (Fig. 225), cut the first arc to obtain the point B (Fig. 226). This method of working is repeated until all the points on the pattern have been obtained, after which curves are drawn from A to C, D to H, J to A, *a* to *c*, *d* to *h*, *j* to *a*, and straight lines from C to D, H to J, *c* to *d*, *h* to *j*, as indicated, to complete the pattern.

CHAPTER IX

Spouting

Pattern for Rain-spout Head.—Fig. 227 represents an elevation and Fig. 228 a half-plan of a spout head which is made in segments, the patterns for which are shown at Figs. 229 and 230, and may be obtained as follows: First divide the elevational curve into a number of distances as illustrated by 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Fig. 227), and from these points draw a series of dotted lines, parallel with the central line, in order to obtain the points marked similarly on the half-plan (Fig. 228). To draw the pattern for one of the two back segments, each of which has one straight side, set off the distances 1 to 10 along the straight line (Fig. 229), making them equal to the distances from 1 to 10 on the elevational curve (Fig. 227). Now make 1 *a*, 2 *b*, 3 *c*, 4 *d*, 5 *e*, 6 *f*, etc. (Fig. 229), equal to 1 *a*, 2 *b*, 3 *c*, 4 *d*, 5 *e*, 6 *f*, etc. (Fig. 228), then draw a curve from *a* through the points thus obtained to *k* (Fig. 229) to complete the pattern. It will be noted that some of the lines in the plan coincide, but this often happens in patterns of this description. A pattern for one of the three remaining segments—all of which are alike—may be drawn similarly. First set off the distances 1 to 10 along the central line (Fig. 230), making them equal to the distances 1 to 10 on the elevational curve of Fig. 227. Then make 1 *a*, 2 *b*, 3 *c*, 4 *d*, etc., on either side of the central line (Fig. 230) equal to 1′ *a*′, 2′ *b*′, 3′ *c*′, 4′ d′, etc. (Fig. 228). Curves drawn through the points thus obtained complete the pattern. No pattern is shown for the bottom of the

spout head, as this is simply a piece of round pipe which may be made straight or tapered as required.

Pattern for Spout Outlet.—Let Fig. 231 represent the outlet, an end elevation of which is shown in Fig. 232.

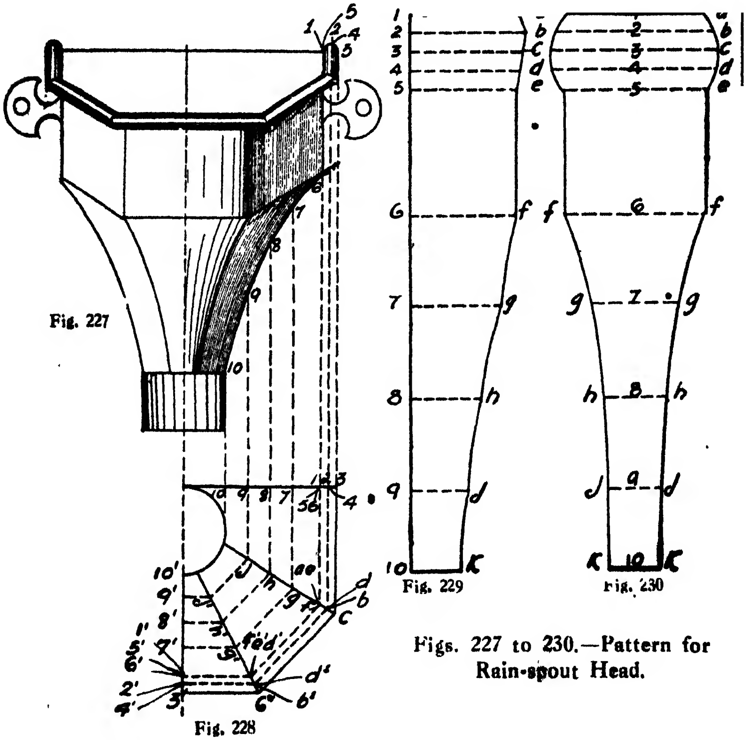


Fig. 227 Fig. 228 Fig. 229 Fig. 230

Figs. 227 to 230.—Pattern for Rain-spout Head.

First describe the dotted quadrant on the base line of Fig. 232, divide it equally as at 1, 2, and 3, and from these points draw the dotted perpendiculars in order to obtain A *a*, B *b*, C *c*, and D *d*. To obtain the pattern (Fig. 233), set off along the line A A twelve distances, each equal to 1 2 (Fig. 232).

Through the points thus obtained erect the dotted vertical lines to meet a series of lines drawn from *a*, *b*, *c*, and *d* (Fig. 232), as indicated. A curve drawn through the points from *a* to *a* (Fig. 233) completes the pattern. The shape of

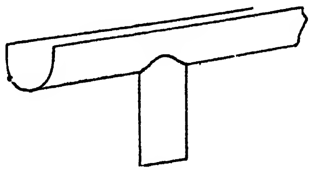


Fig. 231

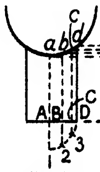


Fig. 232

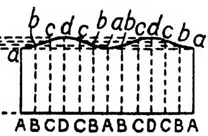


Fig. 233

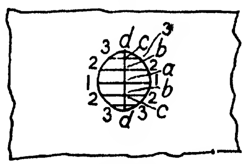


Fig. 234

Figs. 231 to 234.—Pattern for Spout Outlet.

the hole is given in Fig. 234, where *a b c d* equals *a b c d* (Fig. 232). Make *a* 1, *b* 2, and *c* 3 (Fig. 234) equal to A 1, B 2, and C 3 (Fig. 232), and then draw a curve to touch the points thus obtained.

Rectangular Outlet or Shoe.—Fig. 235 represents a rectangular outlet or shoe. In this case two patterns will be required, which can be set out thus: First draw a side elevation of the shoe as at Fig. 236, and let Fig. 237 represent the plan. Draw any line A B (Fig. 236) perpendicular to the sides of the pipe. Similarly, draw C D, and let *a b* represent the junction. Now draw a line H H (Fig. 238), along which

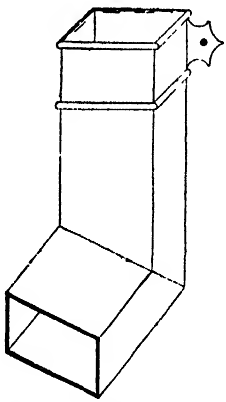


Fig. 235.—Rectangular Shoe.

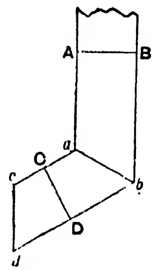


Fig. 236. — Side Elevation of Rectangular Shoe.

set off distances A B, C D, and E A equal to those shown on the plan (Fig. 237). From A, B, C, D, E, and A (Fig. 238) draw lines at right angles to the line H H, and make A *a*, B *b*, E *e*, A *a* (Fig. 238) each equal to B *b* (Fig. 236). Make C *c* and D *d* (Fig. 238) each equal to A *a* (Fig. 236). Join *b c* and *d e* (Fig. 238) and unite *a b*, *c d*, and *e a*, with lines parallel to H H, thus giving a pattern of the A *a*, B *b* part of Fig. 236. The *a b c d* part of Fig. 236 is set out somewhat differently owing to the bevel on both ends of the pipe. First draw a

line D D (Fig. 239), along which set off distances A, B, C, etc., as formerly, to correspond to those of the plan (Fig. 237). Through A B C D E A (Fig. 239) draw lines at right angles to D D, and make A *a*, B *b*, E *e*, and A *a* each equal to D *b* (Fig. 236). Make C *c* and D *d* (Fig. 239) each equal to C *a* (Fig. 236); also make A *a′*, B *b′*, E *e′*, and A *a′* (Fig. 239) each equal to D *d* (Fig. 236), and make C *c′* and D *d′* (Fig. 239) each

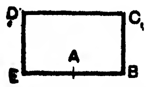
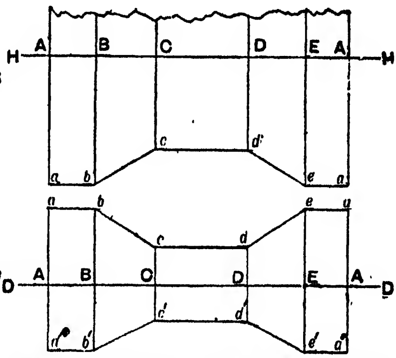


Fig. 237.—Plan of Rectangular Down Pipe.

Fig. 238

Fig. 239



Figs. 238 and 239.—Patterns for Rectangular Shoe.

equal to C *c* (Fig. 236). Unite *a b*, *b c*, etc., with straight lines to complete the pattern.

Patterns for Rectangular Bend.—Fig. 240 shows the side elevation of a similar fitting, with a slow bend instead of a mitred angle. If this shape is required, two pieces are cut equal in all respects to the required side elevation. One is cut equal in length to the required length of curve A B C, and one equal to D E F, both of which are equal in width to the distance D C of Fig. 237. Fig. 241 shows the side elevation of a double bend which is cut out and made

in a similar manner. Fig. 242 shows the side elevation of a double elbow with mitred joints. To obtain a pattern of

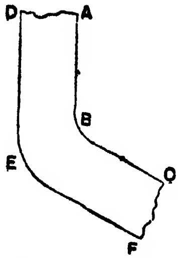


Fig. 240.- Side Elevation of Rectangular Bend.

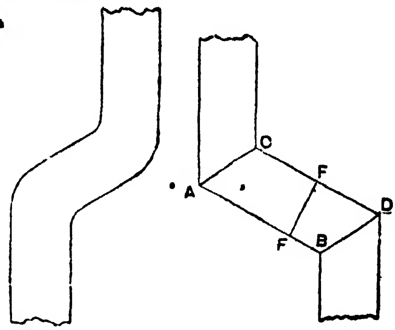


Fig. 241 Fig. 242

Figs. 241 and 242.—Side Elevations of Rectangular Double Bend and Elbow.

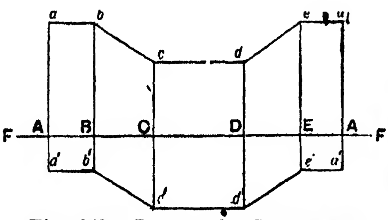


Fig. 243.—Pattern for Rectangular Double Elbow.

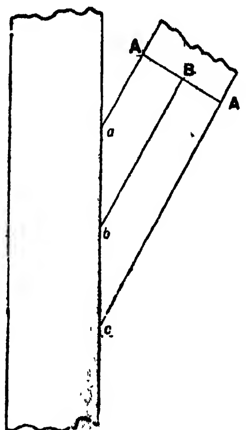


Fig. 244.—Back Elevation of Rectangular Branch Junction.

the centre piece, draw a line FF (Fig. 242) at right angles to the sides of the pipe. Now draw FF (Fig. 243), along

which set off ABCDEA distances equal to those of the plan (Fig. 237), through which draw lines at right angles to the line FF. Make A *a*, B *b*, E *c*, A *a* (Fig. 243) each equal to AF (Fig. 242); also make C *c*, D *d* (Fig. 243) each equal to FC (Fig. 242). Now make A *a'*, B *b'*, E *e'*, A *a'* (Fig. 243) each

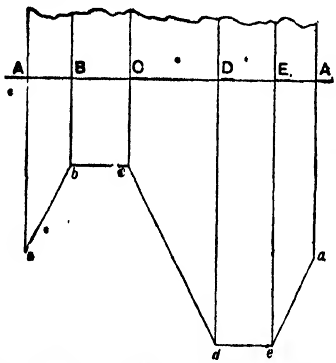


Fig. 245.—Pattern for Rectangular Branch Junction.

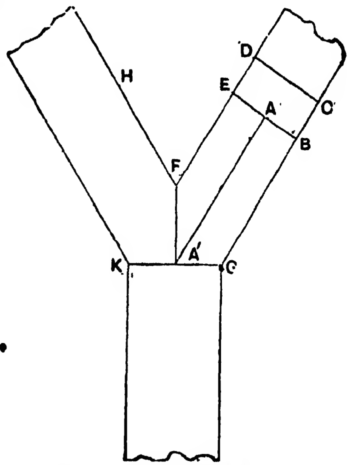


Fig. 246.—Back Elevation of Rectangular Y.

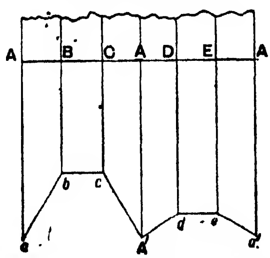


Fig. 247.—Pattern for Rectangular Y.

equal to FB (Fig. 242); also make C *c'*, D *d'* (Fig. 243) each equal to FD (Fig. 242). Join *a b*, *b c*, etc., together with straight lines as shown in Fig. 243, which will then be the correct pattern. The mitres of the end pipes of Fig. 242 can be marked off either end of centre piece (Fig. 243).

Rectangular Branch Junction.—The back elevation of a branch junction is shown in Fig. 244. To obtain a pattern, first draw A A (Fig. 244), at right angles to the sides of the pipe, and from B on the centre of the line A A draw B *b* parallel to the sides of the pipe. On Fig. 245 draw a line A A, along which set off A B C, etc., distances corresponding to those of the plan (Fig. 237). Through the points of division draw lines at right angles to the line A A, and make A *a* (Fig. 245) equal to B *b* (Fig. 244). Make B *b* and C *c* (Fig. 245) each equal to A *a* (Fig. 244), and make D *d* and E *e* (Fig. 245) each equal to A *c* (Fig. 244). Join *a b*, *b c*, etc. (Fig. 245), which will give the required pattern.

Rectangular Y-spout.—Fig. 246 shows the back elevation of a Y whose plan is represented by B C D E, the seam being shown at A A′. To set out the pattern for one of the arms, from which the other can be marked, draw a line A A (Fig. 247), along which set off distances A B, C D, E A, equal to those of the plan. Through the points of division draw lines at right angles to A A. Make C A (Fig. 247) equal to B A, and draw A A′ parallel to C *c* and equal to A A′ (Fig. 246). Make A *a*, A*a*′ (Fig. 247) each equal to A A′ (Fig. 246); also make B *b*, C *c* (Fig. 247) each equal to E F (Fig. 246), and make D *d* and E *e* (Fig. 247) each equal to B G (Fig. 246). Join together the terminals with straight lines to give the pattern required.

Half-round Eaves Spout Angle.—Fig. 248 represents a half-round eaves spout angle, a pattern for which is set out as follows: First draw the plan of the proposed angle (Fig. 249), and from the centre of a line A G, drawn at right angles to A *a*, describe a semicircle, which is then divided into six equal parts. Through the points of division draw lines B *b*, C *c*, D *d*, E *e*, F *f*, parallel to A *a*. Now draw Fig. 250, and along the line A G set off the six equal parts of the

semicircle, as at BCDEF. Through these points draw lines at right angles to the line AG, and make Aa (Fig. 250) equal

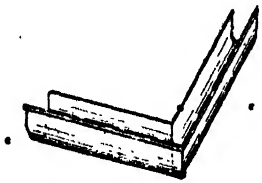


Fig. 248. — Half-round Eaves Spout Angle.

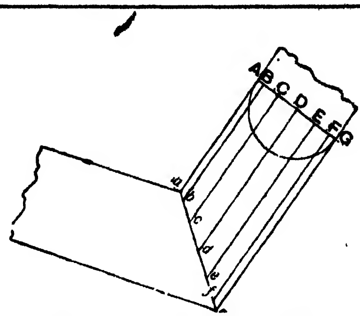


Fig. 249. – Plan of Half-round Eaves Spout Angle.

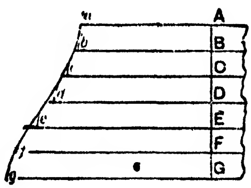


Fig. 250.—Method of Setting Out Half-round Eaves Spout Angle.

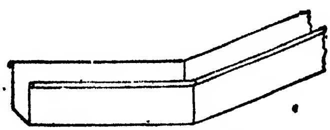


Fig. 251. – Square Eaves Spout Angle.

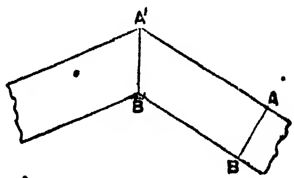


Fig. 252. – Plan of Square Eaves Spout Angle.

to Aa (Fig. 249). Similarly, transfer respectively the lengths of the other lines, which are marked coincidently, and draw

a curve to touch the respective ends of the lines, which will give the pattern of one-half of the angle.

Square Eaves Spout Angle.—Fig. 251 shows an angle of square eaves spouting. In setting out the pattern, draw first a plan of the proposed angle (Fig. 252) and also a section of the spout as in Fig. 253. Draw a line AB (Fig. 252) at right angles to the sides of the spout. Now draw a line AB (Fig. 254), make A*a* (Fig. 254) equal to A*a* (Fig. 253), make *ab* and *b*B (Fig. 253) equal respectively to AB and *b*B (Fig. 253), and through the points of division draw lines at right angles to AB. Now make AA′ and *aa′* each equal to AA′ (Fig. 252), and make *bb′* and BB′ (Fig. 254) each equal to AA (Fig. 252), and make *bb′* and BB′ (Fig. 254) each equal to BB′ (Fig. 252). Join A′*a′*, *a′b′*, and *b′*B′ (Fig. 254) with straight lines, which will give the pattern of one-half of the proposed angle. The other half can be marked off this, after due allowance has been made for wiring edges and lap.

Ogee Spouting.—Fig. 255 represents a piece of eaves spout with a moulded front, commonly known as ogee spouting. To obtain a pattern of an angle of this kind of spouting, first draw the plan of the proposed angle (Fig. 256), and at one end draw a section of the angle as shown in the figure, so that AJ represents the width of the spout, and IJ the depth of the back. Divide the curved line of the section B to H into any number of equal parts, as at C, D, E, F, G, and from these points draw projectors parallel to the sides of the angle until they cut the plan line of the junction in *c′*, *d′*, *e′*, *f′*, *g′*, *h′*. Now along a straight line (Fig. 257) transfer the respective distances of the section AB, C, D, E, F, G, H, I, and J, and from these points draw lines at right angles to the straight line already drawn. Make A*a* (Fig. 257) equal to A^1a^1 (Fig. 256), and as B coincides with A^1a^1,

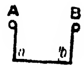


Fig. 253.—Section of Square Eaves Spout Angle.

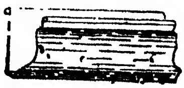


Fig. 255.—Piece of Ogee Eaves Spout.

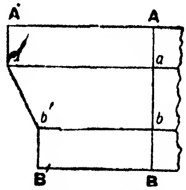


Fig. 254.—Method of Setting Out Square Eaves Spout Angle.

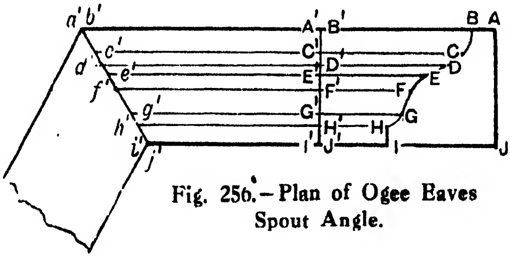


Fig. 256.—Plan of Ogee Eaves Spout Angle.

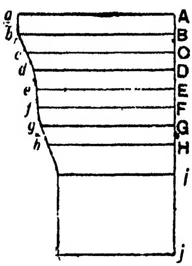


Fig. 257.—Method of Setting Out Ogee Eaves Spout Angle.

make B b (Fig. 257) equal to $A^1 a^1$ (Fig. 256). Make C c, D d, E e, F f, G g, and H h (Fig. 257) each equal respectively to $C^1 c^1$, $D^1 d^1$, $E^1 e^1$, $F f^1$, $G^1 g^1$, $H^1 h$ (Fig. 256). As I and J coincide on the line J j^1 (Fig. 256), make I i and J j (Fig. 257) each equal to J j^1 (Fig. 256). From a to b, h to i, and i to j (Fig. 257) draw straight lines and a curved line from b to h, which will give the pattern for $A^1 a^1$, $J^1 j^1$ (Fig. 256).

CHAPTER X

Pyramids

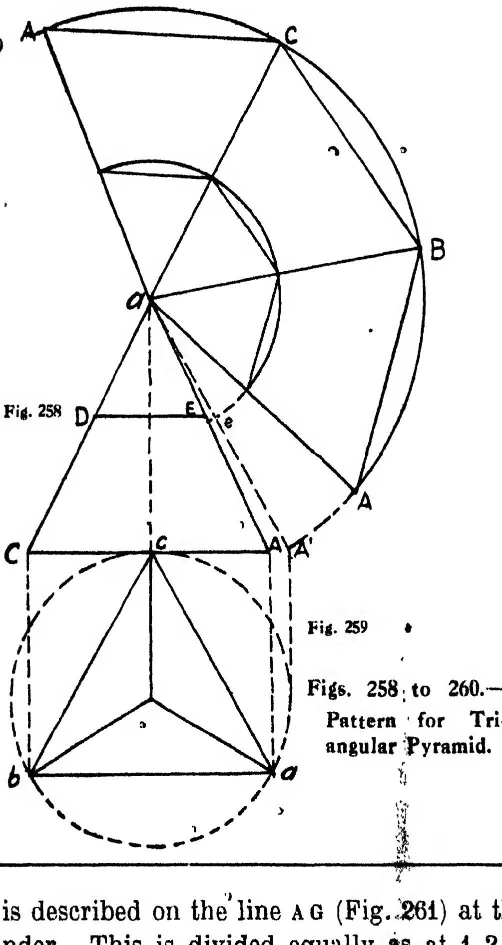
A PYRAMID, or in other words a pyramidal body, is one that stands on a triangular, square, or polygonal base, and tapers to a point at the top. Each side of any pyramid is therefore a triangle. A pattern for any pyramid consists of a number of triangles joined together, and the number of triangles which constitute the pattern depends on whether the pyramid is triangular, square, hexagonal, or other shape.

Pattern for Triangular Pyramid.—Let A C *a* (Fig. 258) represent an elevation of a triangular pyramid, and *a*, *b*, *c* (Fig. 259) a plan drawn within the circumscribing dotted circle. First draw the vertical dotted line from the edge of the circle to give A′ on the base line (Fig. 258), then join A′ to *a*. To draw the pattern Fig. 260 use *a* as centre and describe an arc from A′ (Fig. 258). Make A, B, C, A (Fig. 260) equal to *a*, *b*, *c*, *a* (Fig. 259). Join A, B, C, A and *a* (Fig. 260) as indicated to give the required pattern.

In the event of a pattern being required for a truncated pyramid, such as is represented by D, E, C, A (Fig. 258), produce D E to obtain *e*, then with *a* as centre draw an arc, and join up the points on the pattern as illustrated.

Cylinder Intersecting Triangular Pyramid.—Let O K′H (Fig. 261) represent an elevation of a triangular pyramid which is intersected by the cylinder A *a*, G *g*. A plan of the pyramid is shown by Fig. 262. How to obtain a pattern for the pyramid has already been explained in the previous

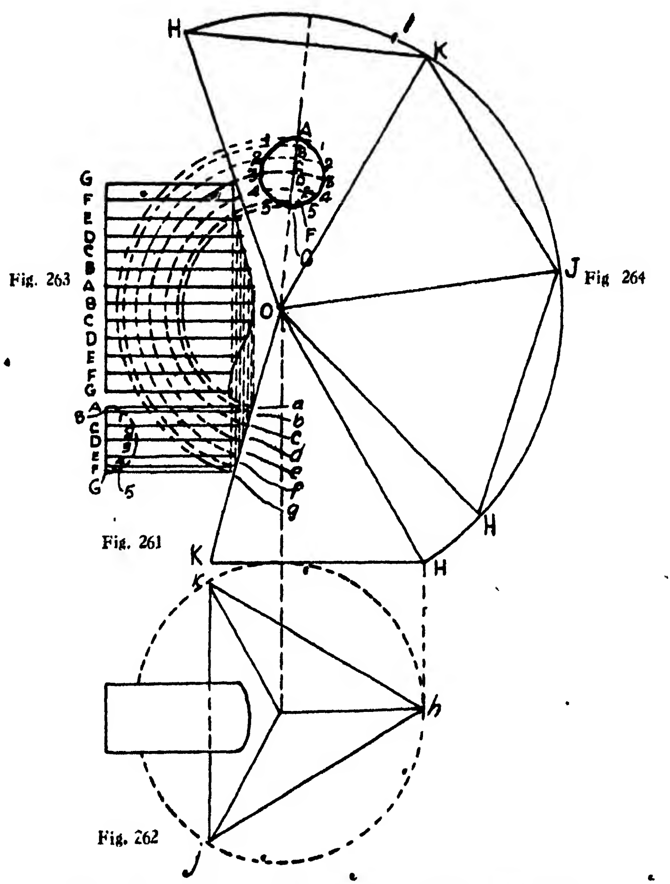
example. The shape of the hole of penetration, however, requires marking on the pattern, and a pattern is also required for the cylinder. As in previous instances, a



Figs. 258 to 260.—Pattern for Triangular Pyramid.

semicircle is described on the line A G (Fig. 261) at the end of the cylinder. This is divided equally as at 1, 2, 3, 4, 5, and lines are drawn through these points to give b, c, d, e, f

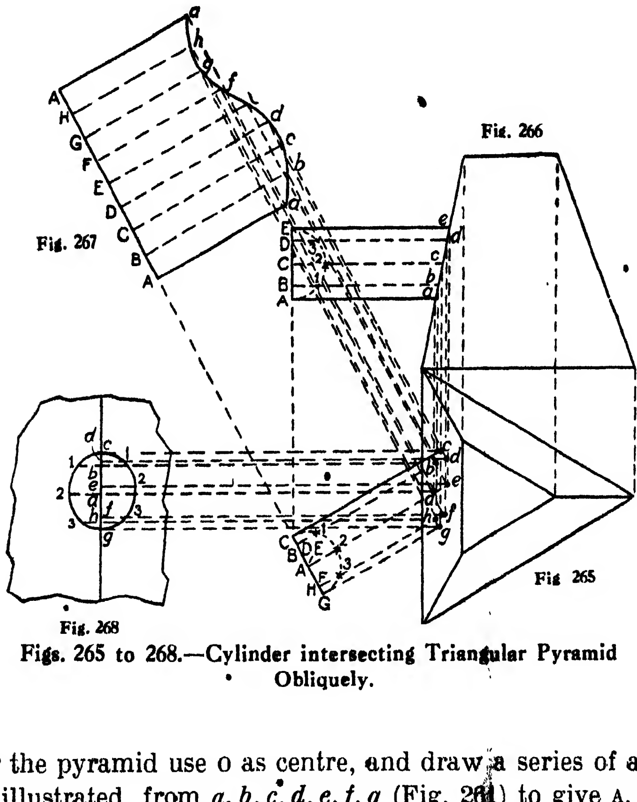
on the junction line. A pattern for the cylinder is shown by Fig. 263, where the distances from G to G equal twice



Figs. 261 to 264.—Pattern for Cylinder intersecting Triangular Pyramid.

the number contained in the dotted semicircle (Fig. 261). A series of lines are now drawn at right angles from A, B,

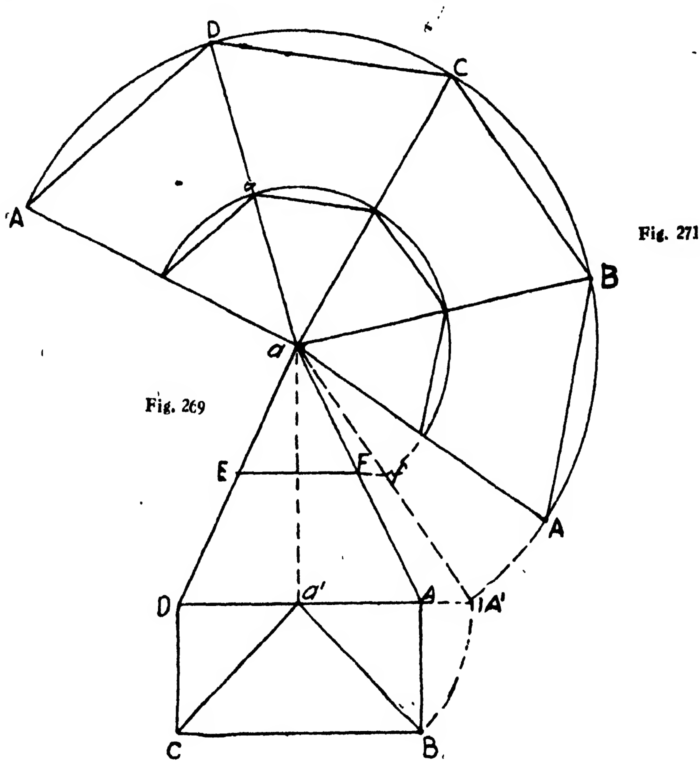
C, D, E, F, G (Fig. 263) to cut another series of lines which are projected from a, b, c, d, e, f, g (Fig. 261), and a curve drawn through the points thus obtained completes the pattern. To obtain the shape of the hole on the pattern



Figs. 265 to 268.—Cylinder intersecting Triangular Pyramid Obliquely.

for the pyramid use O as centre, and draw a series of arcs, as illustrated, from a, b, c, d, e, f, g (Fig. 261) to give A, B, C, D, E, F, G (Fig. 264) Make B 1, C 2, D 3, E 4, F 5 on either side of the central line (Fig. 264) equal respectively B 1, C 2, D 3, E 4, F 5 (Fig. 261), then draw a curve to unite all the points obtained.

Cylinder Intersecting Triangular Pyramid Obliquely. -This is a similar problem to the foregoing, except that

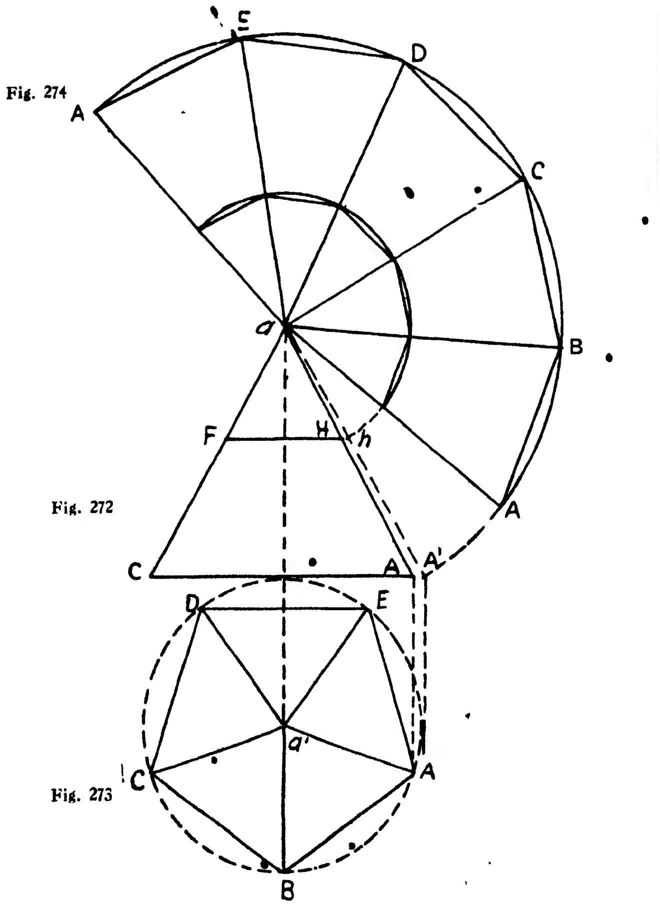


Figs. 269 to 271.—Pattern for Square Pyramid.

the cylinder intersects the pyramid obliquely, as will be seen from the plan (Fig. 265).

First arrange the elevation and plan as illustrated by Figs. 265 and 266. On the end of the pipe E A (Fig. 266) describe the dotted semicircle which divide equally, as at

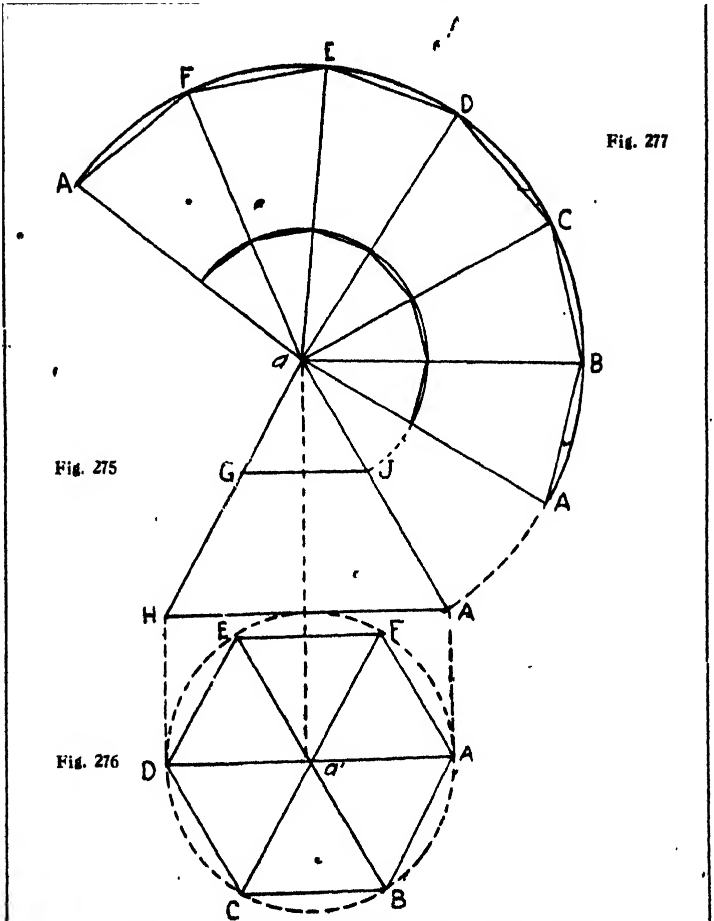
1, 2, and 3, and through these latter points draw lines parallel with the sides of the pipe in order to obtain *e d c b a*



Figs. 272 to 274.—Pattern for Pentagonal Pyramid.

and EDCBA (Fig. 266). Similarly, on the end of the pipe CG (Fig. 265) draw another dotted semicircle, divide it

equally as at 1, 2 and 3, and through these points draw lines parallel with the sides of the pipe to give B, A, H, *a*, *b*, *c*,



Figs. 275 to 277.—Pattern for Hexagonal Pyramid.

d, *c*, *f*, *g* and *h* (Fig. 265). The latter points are definitely fixed by drawing projectors from *a*, *b*, *c*, *d*, and *e* (Fig. 266),

to cut the lines which are drawn parallel with the sides of the pipe (Fig. 265). To draw the pattern for the pipe, produce

Fig. 280

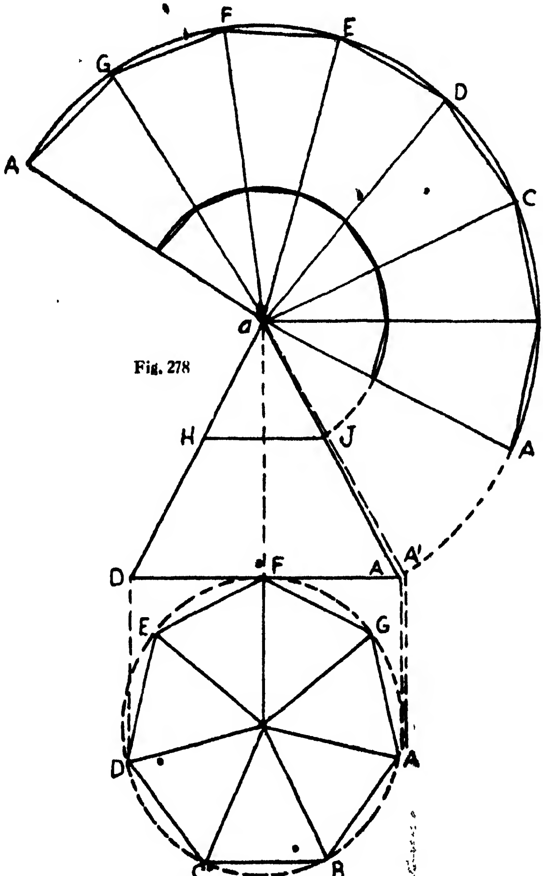


Fig. 279

Fig. 278 to 280.—Pattern for Heptagonal Pyramid.

C G (Fig. 265) to obtain the straight line A A (Fig. 267). The distances B, C, D, E, F, G and H are really twice the number

of distances that are contained in the dotted semicircle on the end of the pipe (Fig. 265); and each distance in Fig. 267

Fig. 283

Fig. 281

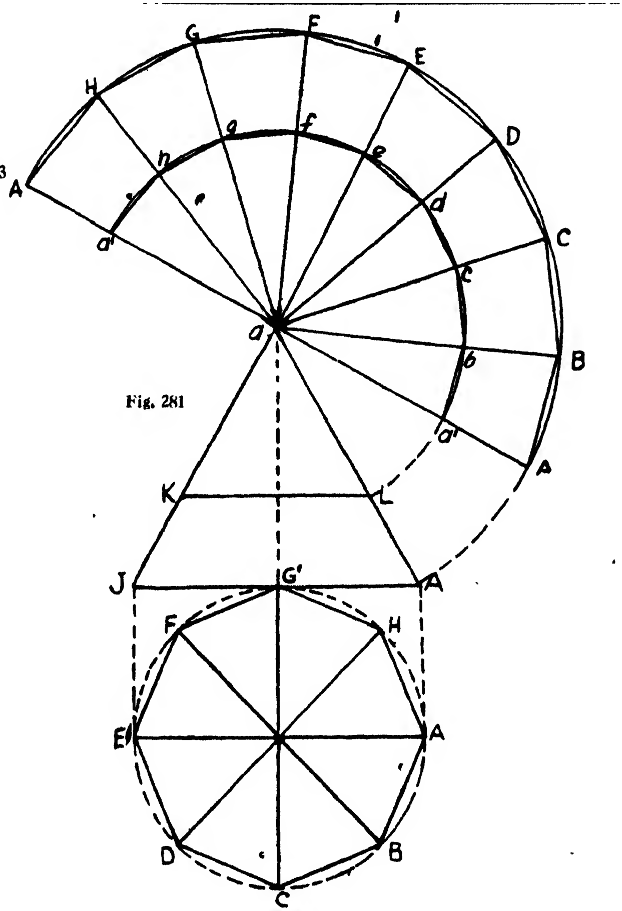


Fig. 282

Fig. 281 to 283.—Pattern for Octagonal Pyramid.

is equal to one of the distances (say 1 2) of the dotted semicircle (Fig. 265). A series of dotted parallel lines is now

drawn from A, B, C, D, E, F, G and H (Fig. 267), as illustrated, to cut a series of dotted lines which are projected from *a*, *b*, *c*, *d*, *e*, *f*, *g* and *h* (Fig. 265), to *a*, *b*, *c*, *d*, *e*, *f*, *g* and *h* (Fig. 267). A curve drawn from *a* to *a* (Fig. 267), passing through the points thus obtained, completes the pattern. The shape of the hole is illustrated in Fig. 268. Lines are projected from *c*, *d*, *b*, *e*, *a*, *f*, *h* and *g* (Fig. 265) to the central line *c g* (Fig. 268). Make *d* 1 and *b* 1 (Fig. 268) equal to D 1 and B 1 (Fig. 265). Similarly make *e* 2 and *a* 2 (Fig. 268) equal to A 2 (Fig. 265), then make *f* 3 and *h* 3 (Fig. 268) equal to F 3 and H 3 (Fig. 265). A curve drawn through *c*, 1, 2, 3, *g*, 3, 2, 1 and *c* (Fig. 268) completes the shape of the hole required. A theoretically perfect shape could only be obtained by taking measurements from Fig. 266 as well as from Fig. 265, but in order to avoid confusing lines the foregoing method is given as one which is sufficiently correct for all practical purposes.

Pattern for Square Pyramid.—An elevation of a square pyramid is shown at D *a* A (Fig. 269), and A, B, C, D, *a′* (Fig. 270), represent a half plan. With *a′* (Fig. 270) as centre draw an arc from B to A′ and unite A′ to *a* (Fig. 269). To draw the pattern Fig. 271 use *a* as centre, and draw an arc from A′ (Fig. 269). Make the distances A, B, C, D, A (Fig. 271) each equal to B, C (Fig. 270). Join A, B, C, D, A, *a* (Fig. 271) with straight lines, as illustrated, to complete the pattern. In the event of a pattern for a truncated pyramid being required simply draw a line E, F (Fig. 269) in any given place, produce the line to give *f* on the line A′ *a*, then with *a* as centre describe an arc from *f*. The rest is self-explanatory.

Pattern for Pentagonal Pyramid.—An elevation of a pentagonal pyramid is shown by A, *a*, C (Fig. 272). A, B, C, D, E (Fig. 273) represent a plan drawn within the circum-

scribing dotted circle. First draw the dotted vertical line from the dotted circle to give A′ (Fig. 272), then join A′ to *a*. With *a* as centre, and radius equal to *a*, A′, draw the arc (Fig. 274). Make A, B, C, D, E, A (Fig. 274) equal to A, B, C, D, E, A (Fig. 273). Join these points together by straight lines, then join them to *a*, as illustrated, to give the pattern (Fig. 274). The line F, H (Fig. 272) is shown simply to illustrate how the pattern for a frustum, or truncated pyramid, may be obtained; as in previous instances.

Pattern for Hexagonal Pyramid.--An elevation of a hexagonal pyramid is represented by H, *a*, A (Fig. 275), and A, B, C, D, E, F (Fig. 276) show its plan drawn within the circumscribing dotted circle. A point worth mentioning here is that when one of the junction lines in plan, such as *a*′ A (Fig. 276, for example), is parallel with the base line H, A (Fig. 275) the slant depth *a*, A of the pyramid is the correct radius for the pattern. But where the junction line in plan is not parallel with the base line, as for example *a*′, A (Fig. 273), then a dotted vertical line must be drawn from the edge of the circumscribing circle to the base line, as illustrated in Fig. 273. This, in effect, produces the same result as would be obtained if one of the junction lines in plan were drawn parallel with the base of the elevation. It is not, of course, necessary in actual practice to draw all the lines illustrated. These are put in here to render the method of working clearer than otherwise it would be. Referring to Fig. 275, it will be seen that the slant depth of the pyramid is used as the radius for the drawing of the pattern Fig. 277. The distances A, B, C, D, E, F, A (Fig. 277) are made equal to A, B, C, D, E, F, A (Fig. 276). Straight lines are then drawn to join up all the points as indicated, after which radial lines are drawn

from the points of division to *a* to complete the pattern. A line G, J (Fig. 275), is drawn to show how the pattern for a frustum may be obtained, as previously described.

Pattern for Heptagonal Pyramid.—An elevation of a heptagonal pyramid is represented by D, *a*, A (Fig. 278). The plan A, B, C, D, E, F, G (Fig. 279) is drawn within a circumscribing circle, and as none of the junction lines shown in plan is parallel with the base of the pyramid, a dotted vertical line is erected from the edge of the circle to give A′ on the base line produced (Fig. 278). A′*a* then becomes the radius for the pattern. With *a* as centre draw an arc from A′ and make A, B, C, D, E, F, G, A (Fig. 280) equal to A, B, C, D, E, F, G, H, A (Fig. 279). Join up the points with straight lines, as in the former examples, to complete the pattern, Fig. 280. The development of the frustum is again shown, the line H, J (Fig. 278) representing an elevation of the top of the truncated pyramid.

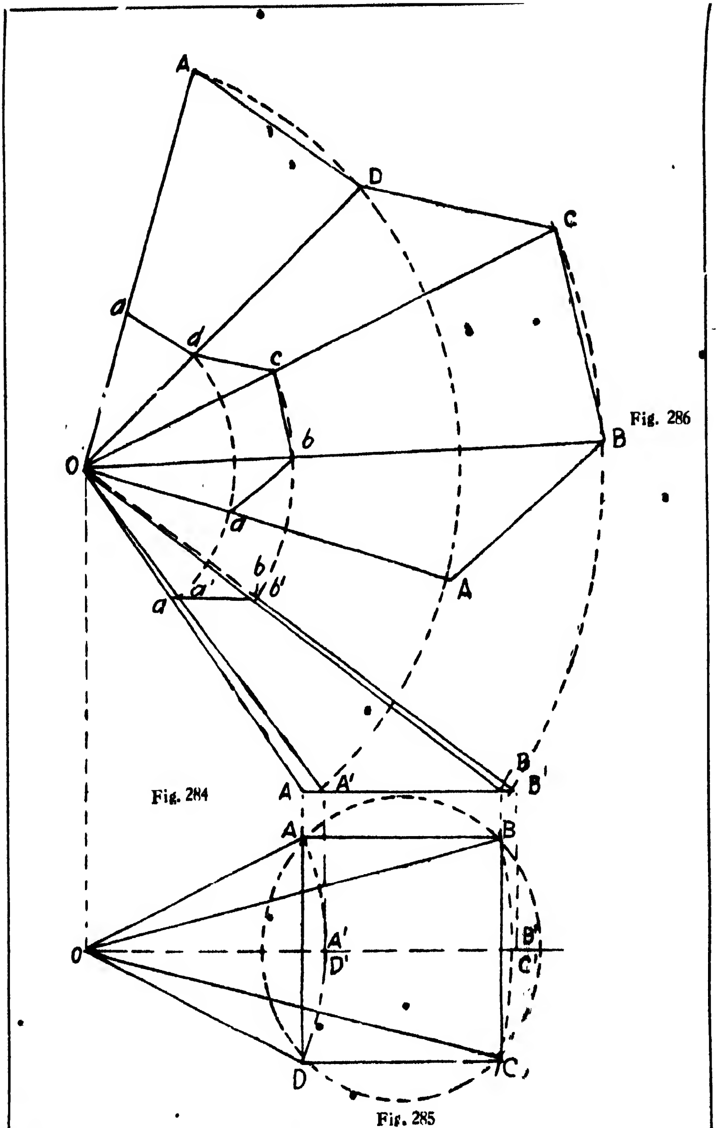
Pattern for Octagonal Pyramid.—An octagonal pyramid is represented by the elevation J, *a*, A (Fig. 281). The plan A, B, C, D, E, F, G, H (Fig. 282) is shown within the circumscribing circle, and, since the plan junction lines E, A (Fig. 282) are parallel with J, A (Fig. 281), the slant length of the pyramid is the correct radius for the pattern. Therefore with *a* (Fig. 281) as centre draw an arc from A, and make A, B, C, D, E, F, G, H, A (Fig. 283) equal to A, B, C, D, E, F, G, H, A (Fig. 282). Join the points thus obtained, as illustrated, to complete the pattern, Fig. 283. In the event of a pattern for a truncated pyramid being required, draw the line KL (Fig. 281) in any given position, then with *a* as centre draw an arc from L to cut the radial lines A*a*, B*a*, C*a*, D*a*, etc. (Fig. 283), as indicated. A series of straight lines are then drawn from one radial line to another to give the points *a′*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *a′* (Fig. 283).

CHAPTER XI

Oblique Pyramids

JUST as oblique cones are encountered in sheet-metal work, so also are oblique pyramids. For present purposes it will be sufficient if we define an oblique pyramid as one which tapers obliquely from its base to its apex. Thus the plan of the apex of an oblique pyramid, unlike that of a right pyramid, must necessarily be out of the centre of the plan of the base. Indeed, in many cases the plan of the apex lies entirely outside the plan of the base, as will be seen in the following examples. In some instances a frustum of an oblique pyramid is required. Some hoods and hoppers, for example, are really portions of square oblique pyramids.

Pattern for Square Oblique Pyramid. Let O, A, B (Fig. 284) represent an elevation of a square oblique pyramid whose plan is shown by A, B, C, D, *o* (Fig. 285). First produce the central dotted line of the plan, then drop the dotted perpendicular from O (Fig. 284) so as to obtain *o* (Fig. 285), which is a plan of the apex. Unite A, B, C, D (Fig. 285) to *o*, then with the latter point as centre draw dotted arcs from A, B, C, D (Fig. 285) to give A′, B′, C′, D′ on the central dotted line of the plan. In this case it will be noted that the points A′ D′ and B′ C′ coincide, but all the points are marked to show the method of procedure, though only two points on the central dotted plan line are really essential, since the plan is a square, two sides of which are parallel with the base line of the elevation.



Figs. 284 to 286.—Pattern for Oblique Square Pyramid.

Vertical dotted lines are now drawn from A′ and B′ to give A′ and B′ on the base line (Fig. 284), and thence to O, the apex. To draw the pattern (Fig. 286) use O as centre, and draw arcs from A′ and B′ (Fig. 284). Make A, B, C, D, A (Fig. 286) equal to A, B, C, D; A (Fig. 285), and join all the points together with straight lines as indicated. Assuming that a pattern is required for the frustum *a*, *b*, A, B (Fig. 284), use O again as centre, and draw the dotted arcs from *a*′ and *b*′. Now join *a*, *b*, *c*, *d*, *a* (Fig. 286) with straight lines to give the pattern required.

Pattern for Oblique Pentagonal Pyramid.—Let O, C, A (Fig. 287) represent an elevation, and A, B, C, D, E, *o* (Fig. 288) a plan of the oblique pentagonal pyramid for which a pattern is required. First produce the central dotted line of the plan, then drop the dotted perpendicular from O (Fig. 287) to give *o* (Fig. 288). With the latter point as centre draw the small dotted arcs from A, B, C, D, E (Fig. 288) to give A′B′C′D′E′ on the central line (Fig. 288), then draw the dotted verticals to give *a*′, *b*′, *c*′, *d*′, *e*′ on the base line (Fig. 287), and join the points on the base line to O. To draw the pattern, Fig. 289; with O as centre draw dotted arcs from *a*′ *e*′ *b*′ *d*′ C (Fig. 287), and make A, B, C, D, E, A (Fig. 289) equal to A, B, C, D, E, A (Fig. 288). It will be noted that point A, in Fig. 289, is on the dotted arc which is drawn from *a*′ (Fig. 287). Similarly, B, C, D, E (Fig. 289) are on those arcs which are drawn respectively from *b*′, C, *d*′, *e*′ (Fig. 287). All the points obtained on Fig. 289 are joined up with straight lines to complete the pattern. The line *c*, *a* (Fig. 287) is drawn to illustrate the frustum, which has been described previously, and the small dotted arcs drawn from *c*, *d*, *b*, *e*, *a* show the method of procedure in arriving at the shape of the pattern.

Pattern for Oblique Hexagonal Pyramid.—An eleva-

Fig. 289

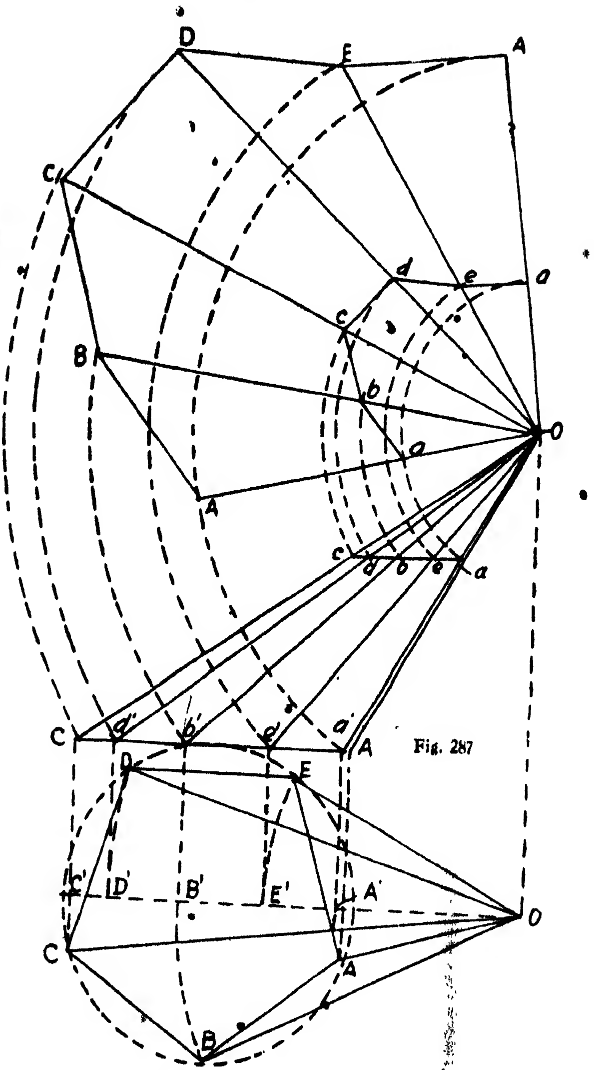


Fig. 287

Fig. 288

Figs. 287 to 289.—Pattern for Oblique Pentagonal Pyramid.

tion of an oblique hexagonal pyramid is shown by D, O, A (Fig. 290), and its plan is represented by A, B, C, D, E, F, *o* (Fig. 291). As in previous instances, first obtain *o*

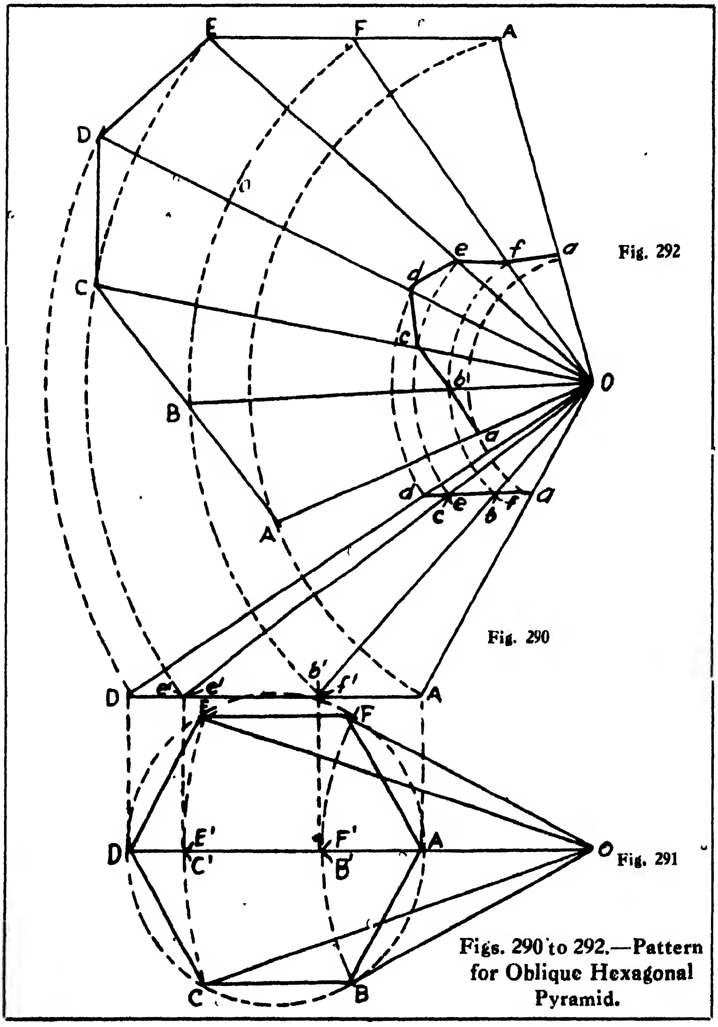


Fig. 292

Fig. 290

Fig. 291

Figs. 290 to 292.—Pattern for Oblique Hexagonal Pyramid.

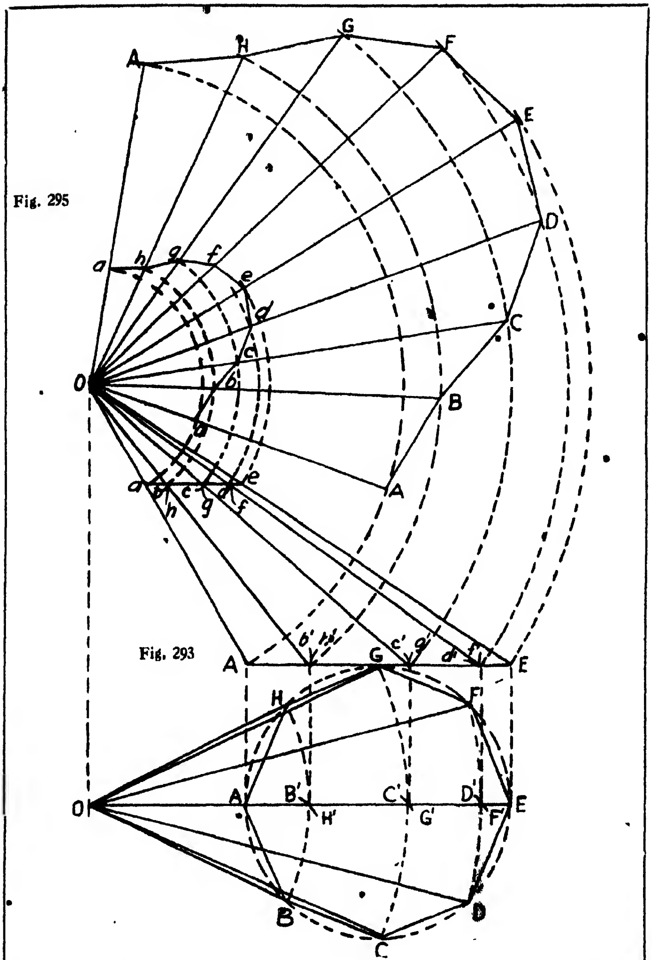


Fig. 295

Fig. 293

Fig. 294

Figs. 293 to 295.—Pattern for Oblique Octagonal Pyramid.

(Fig. 291), then with o as centre draw the small dotted arcs from C, B, E, F to give B′C′E′F′ on the central line of Fig. 291. On these latter points erect the dotted vertical lines to give $b'c'e'f'$ on the base line of the elevation (Fig. 290), then unite the points on the base line to O. To draw the pattern (Fig. 292) use the latter point as centre, and draw dotted arcs from A, $b'c'$D. Make ABCDEFA (Fig. 292 equal to ABCDEFA (Fig. 291), taking care to fix the points in proper order on the right arcs. Then join up the points with straight lines, as illustrated, to complete the pattern. In the event of a frustum being required, draw the line d, a (Fig. 290) in any given position, and with O as centre draw the dotted arcs from a, b, c, d to give the required points on the pattern. The points on the pattern are then united with straight lines. It will be noted that in this example C′ coincides with E′ (Fig. 291). Similarly, F′ coincides with B′. Therefore c' coincides with e' on the base line, and f' also coincides with b'. These coincidences account for C and E on the pattern being obtained from one arc (originating from e' and c'), and B and F on the pattern from another arc (originating from b' and f'). Where such coincidences occur, as in square, hexagonal, and octagonal pyramids, all the necessary points can be obtained from a half plan. In practice the half plan is used, whenever practicable, in preference to a whole plan.

Pattern for Oblique Octagonal Pyramid.—This problem is essentially the same as the preceding one, except that the pyramid is octagonal instead of hexagonal. Fig. 293 shows the elevation, Fig. 294 the plan, and Fig. 295 the pattern. The same method of procedure should be adopted, and after what has already been stated the illustrations should be self-explanatory.

CHAPTER XII

Miscellaneous Problems

Pattern for Copper Kerb for Hearth.—Two illustrations of copper kerbs, showing different styles of repoussé decoration, are shown by Figs. 296 and 297. If desirable, the repoussé work may be omitted and the kerb made plain, but in any case the method of obtaining the pattern will be the same. A wooden kerb of any suitable section, such as is illustrated by Figs. 298 to 300, is first made to the required dimensions, after which it is covered with copper. For a plain kerb rolled copper, about 24 B.W.G., will be most suitable. Let Fig. 301 represent a plan of the kerb and ABCDE a section of the woodwork to be covered. The section should now be conveniently divided, as at BCD, and a series of lines should afterwards be drawn through the points of division to give a number of points *a*, *c*, *d*, *a′ c′ d′* on both mitre lines. In the present case A and B coincide, so the points *a* and *a′* will serve for both. Similarly, E and D coincide, so *d* and *d′* will also serve for both these points. Some sections require more points on the mitre lines than other sections, but the method of procedure is the same for all. The pattern (Fig. 302) is obtained by making ABCDE equal to ABCDE (Fig. 301). A series of lines are now drawn through these points at right angles with the central line, and dotted lines are projected from *a a′ c c′ d d′* (Fig. 301) to cut the series of lines in the points *a a′ b b′ c c′ d d′ e e′*, as illustrated. Unite *a b c d e* and *a′ b′ c′ d′ e′* with straight lines to


Fig. 296


Fig. 297

Figs. 296 and 297.—Copper Kerbs.

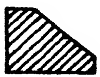


Fig. 298

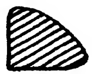
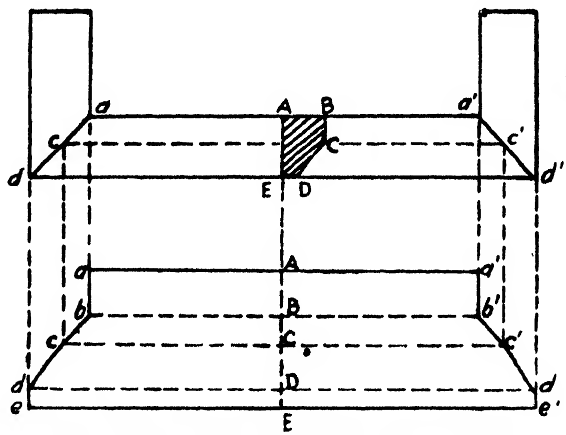


Fig. 299


Fig. 300

Figs. 298 to 300.—Sections of Kerbs.

give the pattern required. Two working edges, each about ½ in. wide, are added to the pattern along the lines aa' and ee'. These are for turning underneath the kerb, where they are nailed or screwed in position. The front mitre will also serve for the side of the kerb, a pattern for which may be marked off the pattern just obtained. Copper kerbs made in this way may be left plain copper,



Figs. 301 and 302.—Patterns for Copper Kerb.

or they may be polished bright and lacquered. Good results can also be obtained by bronzing the copper any selected colour by the application of coloured lacquer. If something between a plain finish and an elaborate repoussé design is required, the copper may be hammered all over with a small bullet hammer, leaving the hammer marks showing.

Making Spirit Blowlamp.—First cut a disc of stout copper or brass to fit tightly inside one end of the cylinder

to constitute the bottom, and solder it in position. Another disc, having a concentric hole to accommodate a collar and screw top A, is cut for the top of the lamp (Fig. 303), but the collar should be soldered to the disc before the disc is soldered to the cylinder. The blowpipe B is bent as shown, and it is then secured to the body of the lamp

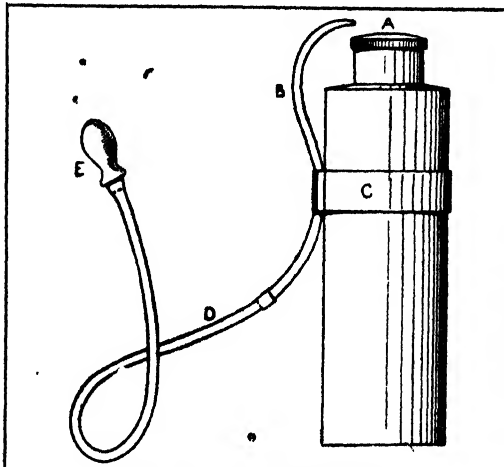


Fig. 303.—Spirit Blowlamp.

by means of the metal strip C. The latter should not be soldered to the lamp, since it is desirable sometimes to slide it up or down the cylinder and thus raise or lower the blowpipe. The blowpipe extension consists of a short length of rubber tubing D and a wooden or rubber teat E. The interior of the lamp should be filled with cotton-wool, which should be saturated with methylated spirit, and it is then ready for use. This lamp will be found very useful for soft-soldering jobs—particularly for lead and compo pipe work—and it is a handy tool for the tinsmith, gas-fitter, or plumber.

Miscellaneous Problems

Geometrical Terms.—Fig. 304 shows rings known as concentric circles. AB is the radius of the largest circle, while AC is the diameter. AD is a quarter circle, or quadrant. ADC represents a semicircle. ADCE, round the curve, is the circumference. ABC (Fig. 305) is a sector; DE (the curve) is an arc; DE (the straight line) is a chord; the cross hatched part FG is a segment; while H, J, K are tangents.

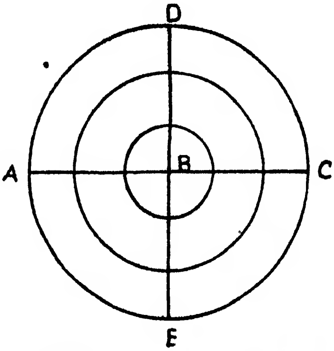


Fig. 304.—Concentric Circles.

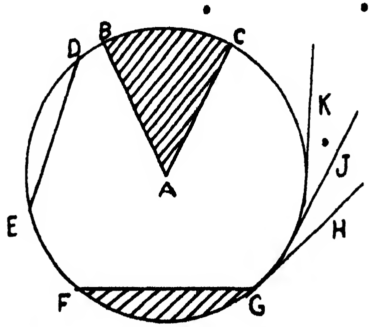


Fig. 305.—Tangent, Sector, Arc, etc., of Circle.

Fig. 306 represents an ellipse; AB is the major axis, and CD the conjugate or minor axis. F and G are the foci. There are several methods of drawing an ellipse, one such method being as follows: With C (Fig. 306) as centre, and radius equal to AE, obtain F and G. Now stick three pins firmly in the points CFG and tie a piece of thread round the three pins to obtain a triangle of thread, as represented by the dotted lines CF, FG, and GC.. Remove the pin at C and replace it with a pencil. The curve drawn by the pencil point will then be an ellipse.

Fig. 307 represents a cone, A is the apex, B C the base, or diameter, and the semicircle is a half plan of the cone. When a cone is cut, as at D E (Fig. 307), the section is a parabola. To draw the parabola, project the dotted lines from D and E to give the lines *c c′* and F F′ (Fig. 308). Make E F and E F′ (Fig. 308) each equal to E F (Fig. 307). Divide F E and F′E (Fig. 308) equally as at 1 2 and 1′2′, then draw a series of dotted lines from these points, as illustrated.

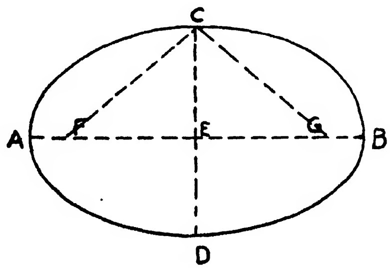


Fig. 306.—Ellipse.

Now divide in a similar manner F *c* and F′ *c′* in order to obtain *a b* and *a′ b′*, then unite these points to D by drawing the straight lines. A curve drawn to pass through the points of intersection from F to D and then to F′ completes (Fig. 308) the parabola required.

When a cone (Fig. 309) is cut, as at A B, the shape of the section is a hyperbola, which may be drawn as follows: First produce E D and B A (Fig. 309) to obtain F, then draw B C. Divide A B equally, as at 1, 2, and from these points project the dotted lines to Fig. 310. Similarly, from F, A, B

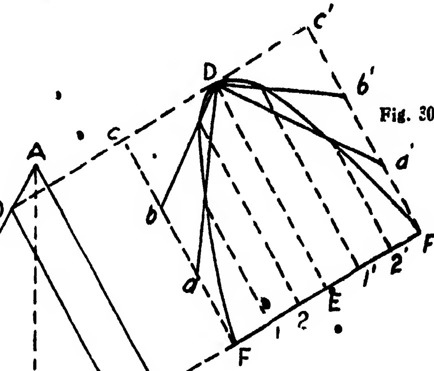


Fig. 308

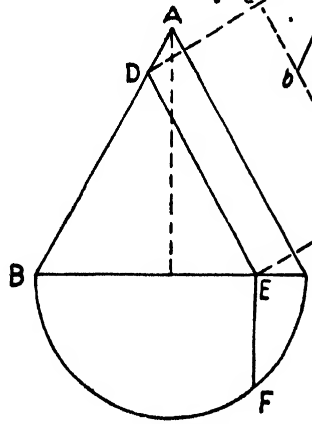


Fig. 307

Figs. 307 and 308.—Drawing a Parabola.

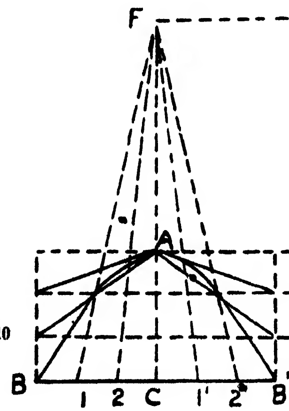


Fig 310

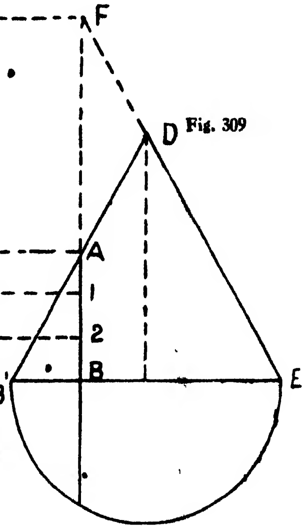


Fig. 309

Figs. 309 and 310.—Drawing a Hyperbola.

(Fig. 309) project other lines to Fig. 310, as indicated. Make CB and CB′ (Fig. 310) each equal to CB (Fig. 309). Divide CB and CB′ (Fig. 310) equally as at 1, 2 and 1′2′, then draw from these points the dotted lines to F. The

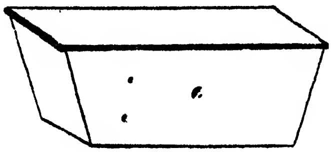


Fig. 311

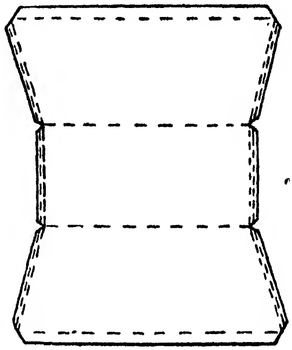


Fig. 312

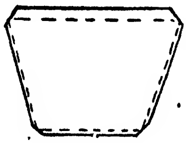


Fig. 313

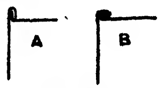


Fig. 314

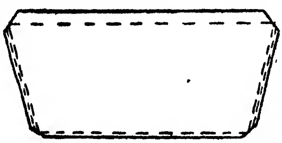


Fig. 315

Figs. 311 to 315.—Patterns for Bakers' Bread Tins.

curve BAB′ (Fig. 310), which is drawn to pass through the intersecting points, as illustrated, gives the hyperbola required.

Making Bakers' Bread Tins.—Bakers' bread tins may be made either in three or five pieces, and they are usually of × × or × × × 20-in. by 14-in. tinplate. Fig. 311 repre-

sents a finished bread tin. Fig. 312 shows a pattern for the sides and bottom of a bread tin that is made according to the three-piece method, while Fig. 313 is a pattern for the ends. Advocates of this method claim that since the sides and bottom of each tin are of one piece, the number of seams is thereby reduced, thus facilitating

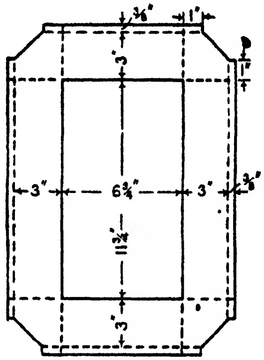


Fig. 316.—Calculating Sizes of Patterns for Rectangular Cooking Pans.

quickness of production. Against this view it is urged (especially where large quantities are dealt with) that the use of the guillotine is practically prohibited owing to the shape of the pattern, thus one of the greatest labour-saving appliances is rendered inoperative. The dotted lines represent working edges, and the seams are "beat up"; A and B (Fig. 314) show respectively sections of the seam before and after beating up. Fig. 315 represents a pattern for the sides, the pattern for the ends where the five-piece method is adopted being the same as that for the three-piece method (see Fig. 313). The bottom, of course, needs no pattern. After the cutting-out process,

begin by folding all the edges. The end edges of the sides are folded right over; the end edges of the ends are folded square. The bottom edges of the sides are folded square in the opposite direction to the end edges, but the bottom edges of the ends are folded square in the same direction. The large wiring edges at the top are folded in the same direction as the bottom edges. Two sides and two ends are now beat together, after which the top is wired with $\frac{3}{16}$-in. rod wire. The bottom is cut, edged, paned on, and beat up in the usual way. Of course, no soldering is required.

Calculating Sizes of Patterns for Rectangular Cooking Pans.—First of all ascertain the size of the bottom of the pan, then add the depth of sides plus wiring allowance. Taking for example a pan measuring 14 in. by 9 in. by 3 in., deduct the total taper and two thicknesses of wire from the length and width respectively. Thus, assuming the total taper to be 2 in. (1 in. on either side), and the pan to be wired with $\frac{1}{8}$-in. iron rod, then

	Length.		*Width.*	
	14		9	
	$2\frac{1}{4}$		$2\frac{1}{4}$	
=	$11\frac{3}{4}$		$6\frac{3}{4}$	the size of the bottom.
Add	6		6	the sides.
and	$\frac{3}{4}$		$\frac{3}{4}$	wiring allowance.
=	$18\frac{1}{2}$	×	$13\frac{1}{2}$	the size of the pattern.

Fig. 316 shows the pattern required, and also illustrates the method of calculating the dimensions.

Pattern for Copper Kettle Spout.—Let Fig. 317 represent an elevation of the spout. First draw the dotted central lines to obtain the point b'', draw a semicircle on

the end of the spout ac, draw a dotted quadrant $a'7$ on the line $a'b'$, and draw the dotted quadrant 456 on the line 34. The pattern is shown at Fig. 318, where abc is equal

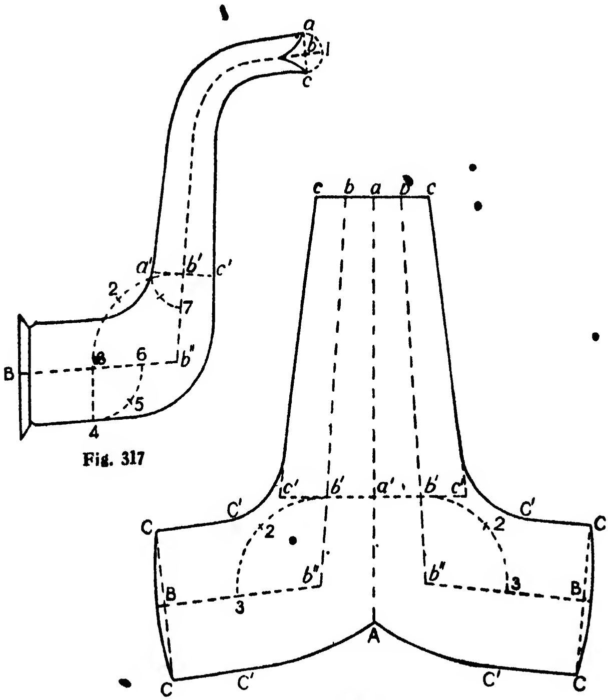


Fig. 317

Fig. 318

Figs. 317 and 318.—Pattern for Copper Kettle Spout.

to the semicircle $a1c$ (Fig. 317). Make b, b' and b'' (Fig. 318) equal to b, b' and b'' (Fig. 317), and make a', b' and c' (Fig. 318) each equal in length to the dotted quadrant $a'7$ (Fig. 317). Now draw the line B b'' (Fig. 318) at the same angle to the line $b'b''$ as they appear in the elevation. This may be readily done by drawing the arc $b'23$ from the

centre b'' and transferring it to Fig. 318 as illustrated. From B (Fig. 318) make BC equal to the dotted quadrant 456 (Fig. 317); similarly from 3 (Fig. 318) obtain C′. Unite CC′ with straight lines, and draw the small curves of the pattern with the compasses set to a radius equal to BC (Fig. 318). The larger curves C′A are drawn with the compasses set to a radius equal to three times the latter radius. In practice it is better to leave the ends CC rounded as illustrated, and the notches at the small end of the spout are best cut after the spout is brazed and bent to shape. The edges c C′ C on both sides of the pattern are brought together first, the small curves being stretched to facilitate this process, and this seam is brazed first. The bottom curved edges A C′ C are then brought together and brazed. The spout should now be trued up on a special bent tool, after which it is loaded with lead and bent carefully at the small end. Should any buckling occur, hammer the surface smooth again before melting out the lead. The inside should now be tinned, the large end trimmed and swaged, and the small end notched and filed to shape with a suitable file. All hand-made spouts of this description are made of one piece of metal. Those made in halves are shaped by machinery.

Pattern for Trough.—It will be seen from the plan, elevation, and sections (Fig. 319) that the trough consists of two unequal portions, which are joined together just where the outlet pipe is placed, from which point the trough tapers, and the section varies in both directions, until the ends become semicircular. Two patterns are required, but only one is here described and illustrated (the smaller portion), since by following the method of working here given the other one may be readily obtained in a similar manner. Let A a G g (Fig. 320) represent an

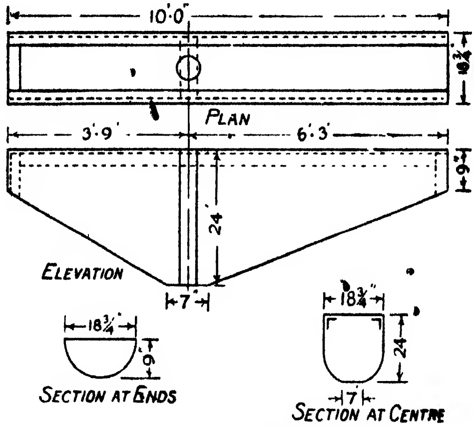


Fig. 319

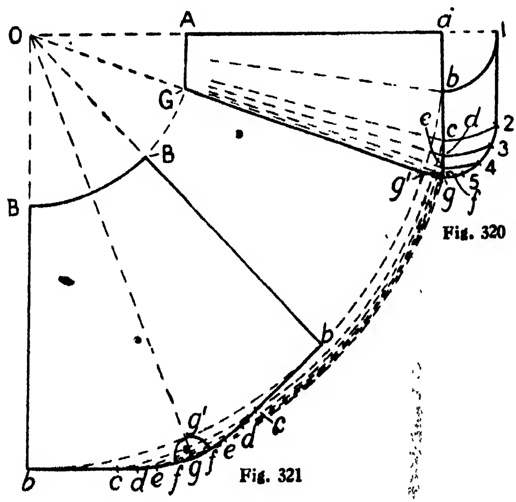
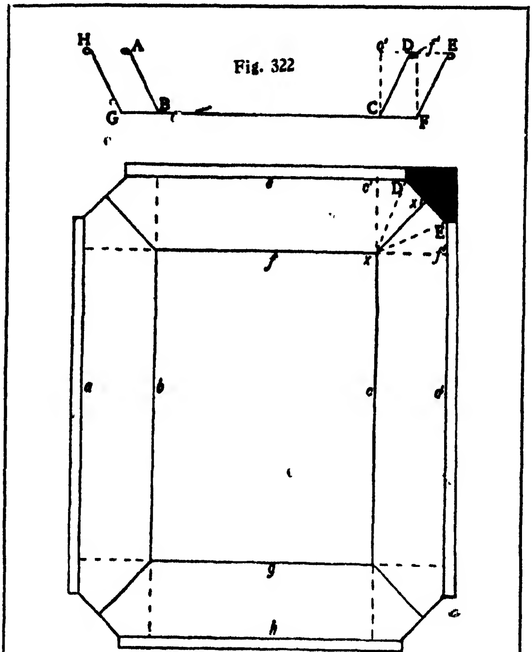


Fig. 320

Fig. 321

Figs. 319 to 321.—Pattern for Trough.

elevation, and 12345g a half-section of the trough on the line ag, the section on A G being a semicircle. First produce A a and G g to meet at O. Divide the curve of the half-section equally as at g, 5, 4, 3, and 2, then with a as centre draw arcs from the points of division, and also from 1, to



Figs. 322 and 323.—Making Baking Pans.

give b, c, d, e, and f, from which points draw dotted lines to O, as indicated. Now with O as centre draw a series of dotted arcs from b, c, d, e, f and g to the pattern (Fig. 321). Set the compasses to one of the divisions of the sectional curve, say g5 (Fig. 320), and step off from g (Fig. 321), on each side of the line gO, the distances f, e, d and c, taking

care to pass from one arc to another in every division; then make *c b* (Fig. 321) equal to 2 1 (Fig. 320). Draw straight lines from *b* to O, and from *b* to *c* (Fig. 321), and a curved line from *c* to *c* to pass through the points *d*, *e*, *f* and *g*. With O as centre draw an arc from G (Fig. 320), to give B B (Fig. 321). The shape of the hole is now required for the outlet pipe. On referring to Fig. 320 it will be seen that an elevation of one-half of the pipe joint is represented by *g′ f*, therefore draw a curve from *g′* to *f* on the pattern (Fig. 321).

Making Baking Pans.—Let A B C D (Fig. 322) represent a section of the width of the pan, and E F G H a section of the length. The amount of taper between the top and bottom widths of the pan is shown by *c′* D, while the amount of taper between the top and bottom lengths of the pan is shown by *f′* E. To draw the pattern (Fig. 323) make *a b c d* equal to A B C D (Fig. 322), and make *e f g h* (Fig. 323) equal to E F G H (Fig. 322). Now set off *c′* D (Fig. 323) equal to the amount of taper *c′* D (Fig. 322). Similarly make *f′* E (Fig. 323) equal to *f′* E (Fig. 322), then unite D E (Fig. 323). The necessary allowance for wiring is added, as indicated; and if the cross-hatched corner piece is cut out, it will serve as a pattern for the other corners. Before bending the pan to shape, the line X X′ at each of the four corners should be struck with the mallet over a hatchet stake; and while the line is resting over the hatchet stake the metal is forced downwards by placing the thumbs at D and E, and exerting pressure, preferably in a series of jerks. The sides of the pan are then worked up by malleting the metal over a square pan stake until the corners D and E (Fig. 323) are brought together. See that the pan is true and square, and free from twist, then flatten the corners with the mallet on the stake and knock them over

until the line XX′ (Fig. 323) coincides with the line c'X. Now set off the wiring edge round the pan, and wire it with wire of a suitable strength, taking care that the meeting of the wire occurs at the middle of the end of the pan. No. 12 B.W.G. wire is suitable for small-size pans, and $\frac{3}{16}$ in. rod wire for large pans. A handle may be made by bending a length of wire to shape and then folding a strip of

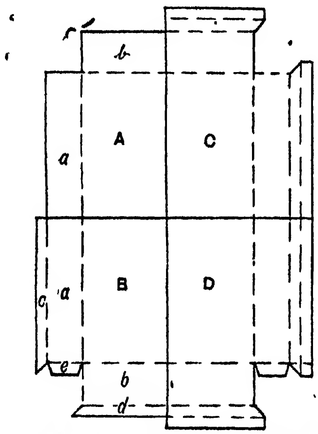
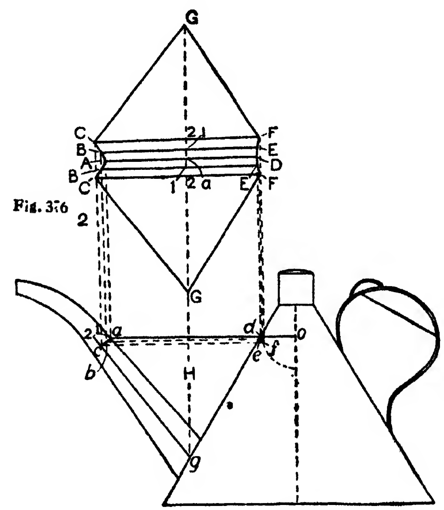


Fig. 324.—Lining Wooden Sink with Copper.

tinplate over it to form a hinge, which should afterwards be riveted to the baking pan in the centre of that end where the wire meets. Large pans require a pair of handles—one at each end of the pan.

Lining Wooden Sink with Copper.—Assuming the sink to be rectangular in shape, with the sides and ends at right angles to the bottom, the lining might be made in one piece. A, B, C, D in Fig 324 represent four alternate patterns for one corner of the lining, either of which might be

employed. For instance, A represents a pattern for one corner of a simple lining, where the side *a* and the end *b* are bent along the dotted lines until they are at right angles to the bottom A, the corner, of course, being soldered inside. If it is required to cover the top of the sink (that



Figs. 325 and 326.—Pattern for Oil-can Boss.

is, the thickness of the wood) with metal in addition to lining the interior, and if a stronger corner joint is considered preferable, then the corner pattern B would be suitable. This is essentially the same as A, except that the lap *c* is bent at right angles to *a*, so that when *a* and *b* are bent to shape the lap *c* will clip, and thus strengthen *b*; further, the edges *c* and *d* are bent along the dotted lines out-

wardly, and at right angles to *a* and *b* respectively, to form a flange which will rest on the top of the woodwork. From the foregoing it will be seen that the corner patterns C and D are further provided with edges additional to those previously mentioned. These outer edges are intended to be bent on to the outer top surface of the woodwork, thus obviating on the extreme top of the sink any raw edges

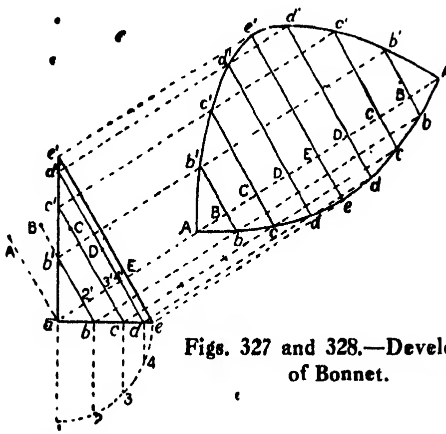


Fig. 328

Fig. 327

Figs. 327 and 328.—Development of Bonnet.

which would otherwise occur. All the soldering of the corners should be inside, a good body of solder being afterwards floated in each corner. This not only strengthens the joint, but greatly improves the appearance.

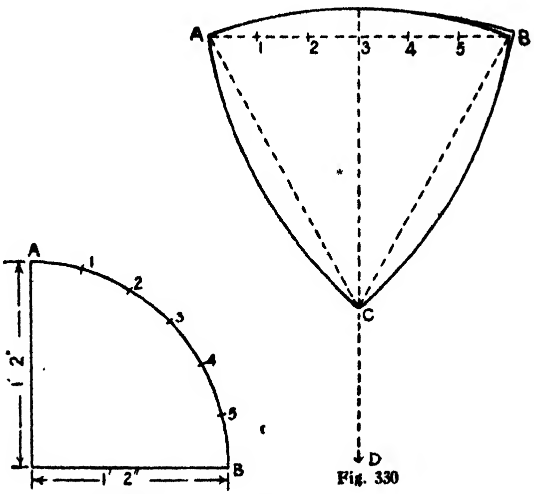
Pattern for Oil-can Boss.—Let H (Fig. 325) represent the boss for which a pattern is required. With *c* as centre, draw the quadrant *a*2, divide it equally as at 1, from which point obtain *b*; then from *a*, *b* and *c* draw parallel lines to cut the quadrant drawn from the centre *o* in the points *d*, *e*, and *f*. To draw the pattern (Fig. 326), make

a 12 equal to *a* 12 (Fig. 325), and then draw the parallel lines as indicated. Lines are now projected from *a*, *b*, *c*, *d*, *e*, and *f* (Fig. 325) to cut the parallel lines in the points marked A, B, C, D, E, and F (Fig. 326). Make C G (Fig. 326) equal to *c g* (Fig. 325); unite C, G, and F (Fig. 326), with straight lines and draw curves from C to C and F to F as illustrated, to complete the pattern.

Development of Bonnet.—Let Fig. 327 represent a side elevation and half-plan of the bonnet. Divide the half-plan equally as at 1, 2, 3 and 4, from which points draw the dotted lines to the base in order to obtain *a*, *b*, *c*, *d*, and *e*. From the latter points lines are now drawn parallel with *e e′* in order to obtain *b′*, *c′*, and *d′*. The distances *a* 1, *b* 2, *c* 3, and *d* 4 are set off from the line E *a* so as to obtain A, B, C, and D. To obtain the pattern (Fig. 328) set off along the line A A the distances A, B, C, D, and E, making them equal to those marked A, B, C, D, and E (Fig. 327), and then draw lines through the points thus obtained, parallel with *e e′* (Fig. 327). Dotted lines are now projected from Fig. 327 to cut the parallel lines as indicated, and curves drawn through the intersections from A to A (Fig. 328) complete the pattern.

Pattern for Rounded Corner of Tank.—A body having a compound curved surface cannot be accurately developed in the usual way. If an orange be cut in halves, and one of the halves be cut in four parts, then one of the latter parts will represent the shape (a quarter of a hemisphere) for which a pattern is now required. If that part is now peeled, and an attempt is made to make the peel lie perfectly flat the foregoing proposition becomes obvious. However, a pattern sufficiently accurate for practical purposes may be set out as follows: Let Fig. 329 represent an elevation of one of the corners, divide the curve A B into six

equal parts as shown at 1, 2, 3, 4, 5, and transfer these distances along a straight line AB (Fig. 330). With A or B (Fig. 330) as centre, and compasses set to AB, obtain the point C, and join AB and C with dotted lines. Allowance for contraction due to hollowing is made by striking curves from point to point as indicated. Thus the curve AB may



Figs. 329 and 330.—Pattern for Rounded Corner of Tank.

be struck from D. A further allowance must be made at the corners to compensate for shrinkage, as shown at B (Fig. 330).

Developing Spherical Surfaces.—A spherical surface is not strictly developable owing to its compound curvature; but, notwithstanding this, patterns or templates may be set out for most spherical surfaces, and prove sufficiently accurate for all practical purposes. The dome of a boiler,

in this instance, may be any segment of a sphere up to, and including, a hemisphere. The pattern for such a dome would be a disc, and the diameter of the disc depends on the height of the dome. Thus, let FAE (Fig. 331)

Fig. 331

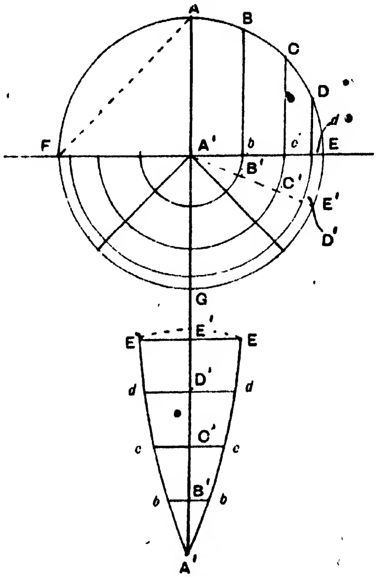
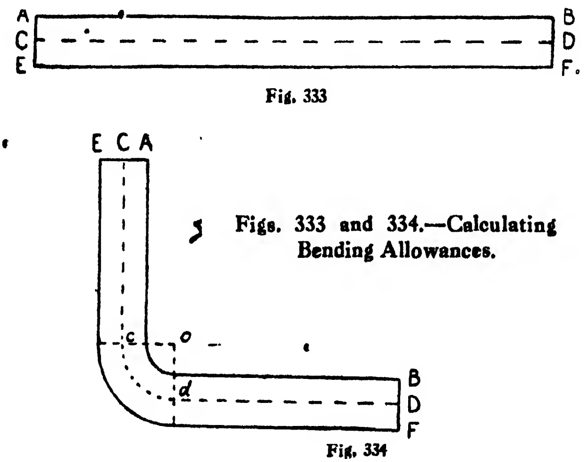


Fig. 332

Figs. 331 and 332.—Developing Spherical Surfaces.

represent a hemispherical dome for which a pattern is required. Unite AF with the dotted line as indicated; then the length of this dotted line AF will represent the radius of the disc. This method may be used for domes of varying heights, provided always that an elevation of

the dome of the required height be first drawn, from which, of course, the required radius can readily be obtained. The disc, when hollowed to shape, forms the dome; but it should be understood that any working edges that may be required must first be added to the pattern by making the necessary allowance. Another method of working is adopted where the dome is required to be made



Figs. 333 and 334.—Calculating Bending Allowances.

of a number of equal segments, similar, roughly, to those which form a boy's cricket cap. Thus, let FAE (Fig. 331) again represent an elevation of the dome under consideration, and let FA′EG represent a half-plan. Assuming that eight segments are to constitute the dome, then divide the half-plan into four and draw radial lines to the centre from the points of division. (In practice it is only necessary to draw a plan of one segment.) Now divide the elevational curve AE (Fig. 331) into a number of equal

parts, as at B, C, and D, and from these latter points draw vertical lines parallel with A A′, in order to obtain *b*, *c*, and *d*, from which points draw the series of arcs, as illustrated, in order to obtain B′, C′, D′, and E′ on the dotted central line of the segment in plan. To draw the pattern (Fig. 332) make A′ B′ C′ D′ E′ equal to A B C D E (Fig. 331), and then draw straight lines through the points of division, at right angles with the central line A′ E′ (Fig. 332). Make B′ *b*, C′ *c*, D′ *d*, and E′ E on each side of the central line in Fig. 332 equal to B′ *b*, C′ *c*, D′ *d* and E′ E respectively in Fig.

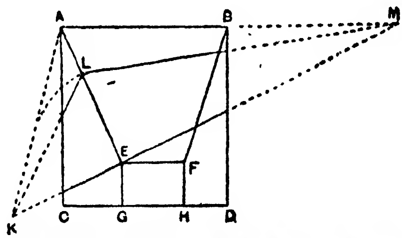


Fig. 335.—Obtaining Bevels of Angles for Coal Bunkers.

331. Draw curves to pass through the points thus obtained to complete the pattern. The dotted arc over the line E E (Fig. 332) represents a little extra allowance to compensate for the shrinkage which will take place during the hollowing process.

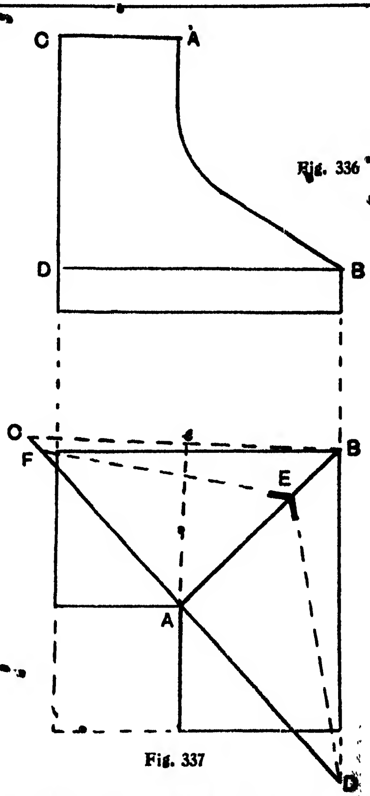
Calculating Bending Allowances.—In order to understand the principle involved, it will first be necessary to appreciate what takes place when a rod of metal is bent to a given shape. Let A B, C D, and E F (Fig. 333) represent such a rod of metal, the ends of which are to be bent in an upward direction until the shape represented by Fig. 334

is obtained. If the line AB (Fig. 334) be measured, it will be found appreciably shorter than it was at AB (Fig. 333). The line EF (Fig. 334) will be found appreciably longer than it was at EF (Fig. 333), but the dotted line CD, in the centre of the rod, will be found to have undergone no change as regards its length. Thus the bending of the rod causes contraction along the inner side and expansion along the outer side, but the central line may be regarded as a neutral axis, or zone, which neither contracts nor expands. In order, therefore, to find the true length of a rod of metal which will assume the shape shown by Fig. 334 (and this also applies to other shapes), one good method is, first draw the shape, and then measure the central line, or neutral axis. To calculate the length, and assuming that *c o* equals 1 in., then the length of the dotted arc *c d* (Fig. 334) will be $\frac{1 \times 2 \times 3.14}{4} = 1.57$ in. By adding the straight lengths C*c* and *d*D (Fig. 334) to the length of the arc thus obtained, the total length is ascertained.

Obtaining Bevels of Angles for Coal Bunkers.—Let ABCDEFGH (Fig. 335) represent the plan of the coal bunker. At right angles to AE draw the line KM. Make EK equal to the upright height of the tapering part of the bunker, and unite KA. Now with E as centre, set the compasses to obtain L, as indicated, and unite K, L, and M, which is the bevel required for that particular corner. The bevel for the corner BF is slightly different, but this may be obtained similarly.

Ascertaining Lengths and Bevels of Angle-bars for Boiler Uptake.—Let Fig. 336 represent one half of the front elevation, and Fig. 337 a portion of the plan (showing the junction AB) of the uptake. First draw the line CD (Fig. 337) at right angles to AB, make AC (Fig. 337) equal

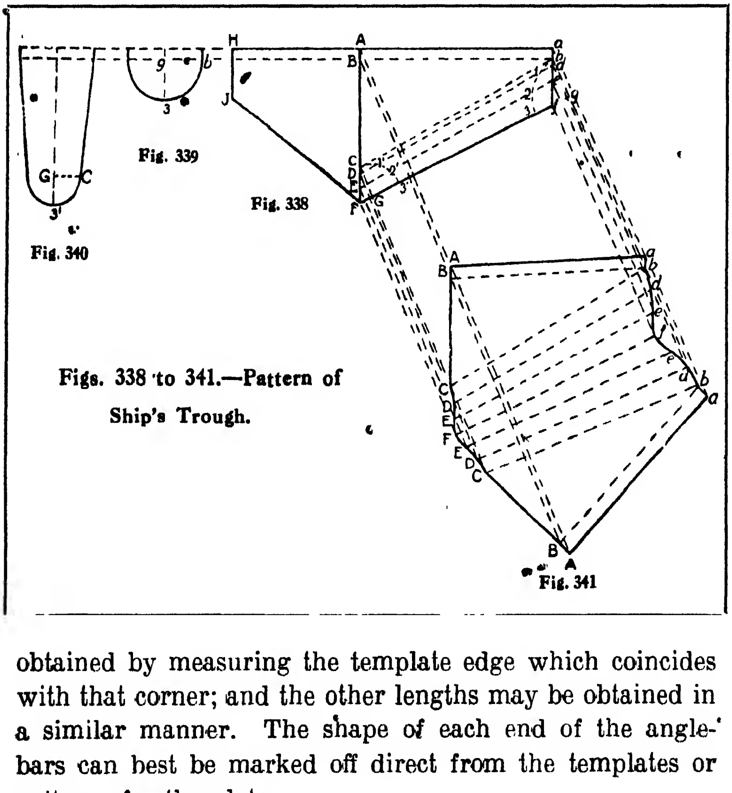
to the upright height of the uptake, as at CD (Fig. 336), then unite CB (Fig. 337) with the dotted line, as indicated. From A (Fig. 337) erect the dotted line A*e* at right angles



Figs. 336 and 337.—Ascertaining Lengths and Bevels for Angle-bars for Boiler Uptake.

to CB, then make AE (Fig. 337) equal to A*e*. The angle FED (Fig. 337) gives the bevel to which the angle-bar for the junction AB must be bent; and the angle-bar is shown

cross-hatched on the junction line. Two angle-bars to this shape will be required for this and the corresponding corner of the uptake; and two other angle-bars will be required to be bent to another bevel (which may be similarly obtained) for the remaining two corners. The length of the angle-bar for the junction AB (Fig. 337) may be

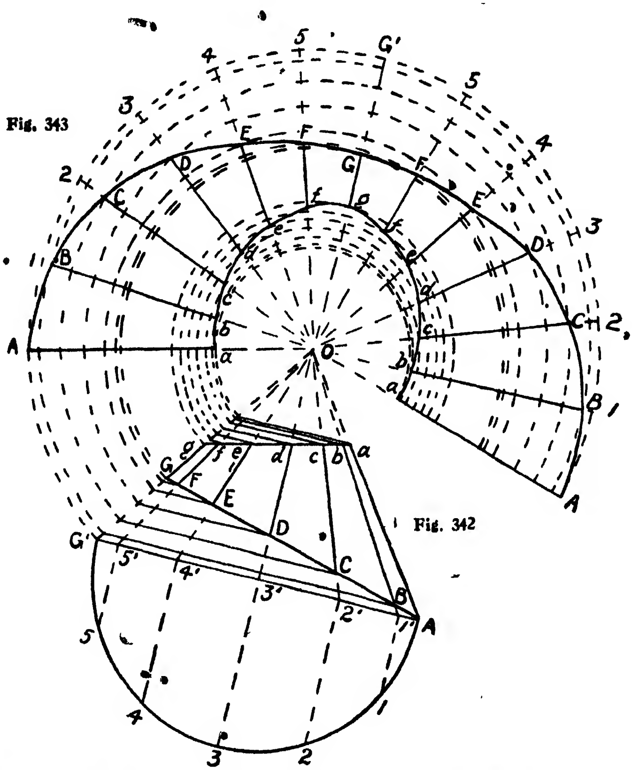


Figs. 338 to 341.—Pattern of Ship's Trough.

obtained by measuring the template edge which coincides with that corner; and the other lengths may be obtained in a similar manner. The shape of each end of the angle-bars can best be marked off direct from the templates or patterns for the plates.

Pattern for Ship's Trough.—Let HJAF*af* (Fig. 388) represent an elevation of the trough for which a pattern is required. Fig. 339 represents a section of the trough at

HJ (Fig. 338), and Fig. 340 represents a section at AF (Fig. 338). Two patterns are really required—one for the HJAF portion of Fig. 338, and the other for AFaf portion



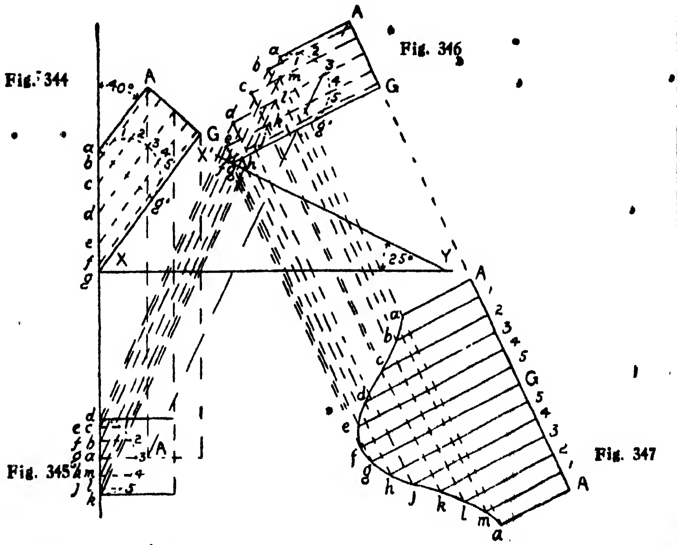
Figs. 342 and 343.—Pattern for Cone Frustum Cut Obliquely.

of Fig. 338. A pattern for the latter portion is given only, but a pattern for the other portion can readily be obtained by adopting the same method of procedure. First draw the quadrant $g\,b\,3$ (Fig. 338), making it equal to the

quadrant $g\,b\,3$ (Fig. 339), and divide it equally as at 1 and 2. Similarly, draw the quadrant GC3′ (Fig. 338), making it equal to the quadrant GC3′ (Fig. 340) and divide it equally as at 1′ and 2′. Draw a dotted line from C to *b* (Fig. 338), then draw dotted lines through 1′, 1, and 2′, 2, in order to obtain DE and *de* (Fig. 338). To obtain the pattern Fig. 341, draw a series of dotted lines from ABCDEF and *abdef* (Fig. 338), making them at right angles with F*f* (Fig. 338). Now set the compasses to one of the divisions of the quadrant C3′ (say 1′2′), then beginning at F (Fig. 341) obtain EDC. Similarly, set the compasses for one of the divisions of the quadrant *b*3 (say 1 2), then starting at *f* (Fig. 341) obtain *d*, *b*. Make CBA (Fig. 341) equal to CBA (Fig. 338); make *ba* (Fig. 341) equal to *ba* (Fig. 338). Draw lines through the points thus obtained, as indicated, to complete the pattern. Any working edges that may be required must be added to the pattern.

Pattern for Cone Frustum Cut Obliquely.—That portion of the cone for which a pattern is required is represented by A*a* and G*g* (Fig. 342). Therefore first produce A*a* and G*g* in order to obtain the complete cone OG′A (Fig. 342). On the base line G′A describe a semicircle, divide it equally as at 1, 2, 3, 4, and 5, then from these points draw a series of dotted lines to the base line, and at right angles with it, in order to obtain the points 1′, 2′, 3′, 4′, and 5′. A series of dotted lines is now drawn from the latter points to the apex O of the cone, so as to obtain *b*, *c*, *d*, *e*, and *f*, and B, C, D, E, and F on that part of the cone for which a pattern is required. Draw lines parallel with the base of the cone from *a*, *b*, *c*, *d*, *e*, and *f*, and B, C, D, E, and F until they touch the left side of the cone, as illustrated in Fig. 342; and from these points draw a series of dotted arcs, as shown in Fig. 343, using O as centre. Now set the com-

passes to one of the divisions of the semicircle, say A1 (Fig. 342), then beginning at A (Fig. 343), step off twice the number of divisions that are contained in the semicircle in order to obtain A, 1, 2, 3, 4, 5, and G′ (Fig. 343). A series of radial lines is then drawn from these points to O, as indicated. The pattern is then obtained by drawing one



Figs. 344 to 347.—Setting Out Pattern for Cylindrical Tube.

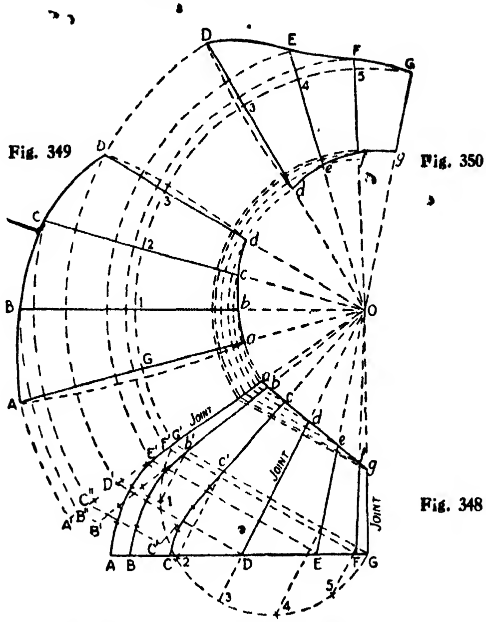
unbroken curve from A*a* to A (Fig. 343) (passing from one dotted arc to another in the space of one division), and another unbroken curve from *a* to *a* similarly, as illustrated. Whatever working edges may be required must be added to the pattern afterwards.

Setting Out Pattern for Cylindrical Tube.—This problem is somewhat complicated—all double-rake problems

are—but with a little patience the reader should soon master the principles involved. The points are marked coincidently so as to make the illustrations, as far as possible, self-explanatory. Let Fig. 344 represent an elevation of the tube inclined at an angle of 40° to the side of the square tank. First describe a semicircle on $a\,g'$, divide it equally as at 1 2 3 4 5, and through these points draw dotted parallel lines to give *b c d e* and *f* as indicated. Now draw the plan (Fig. 345), showing all the essential points of the elevation (Fig. 344). Project A (Fig. 345) from A (Fig. 344). Describe the dotted semicircle on the line *d k* (Fig. 345), divide it equally, as in the former case, and from the points of division draw the short dotted parallel lines to give *a b c d e f g h j k l m* on the vertical line of Fig. 345. Hitherto the rake of the plan has been ignored, but this can now be dealt with by projecting a new elevation (Fig. 346) from the plan (Fig. 345), as illustrated. A new base line X Y is required for this new elevation; and it will be noted that this new base line varies by 25° from the original base line X′Y. Care should be taken to fix the points a A g' as far above the base line X′Y (Fig. 346) as they are above the original base line X Y in Fig. 344. The new elevation contains all the points required for drawing the pattern (Fig. 347). Produce A G (Fig. 346) to give A A (Fig. 347), and make A 1 2 3 4 5 G (Fig. 347) equal to a 1 2 3 4 5 g' (Fig. 346). Now draw a series of parallel lines from A 1 2 3 4 5 G (Fig. 347), making them at right angles to A A. Project another series of lines from *a b c d e f g h j k l m* (Fig. 346) to intersect the former series in the points *a b c d e f g h j k l m* (Fig. 347), as illustrated. A curve drawn from *a* to *a* (Fig. 347) passing through the points thus obtained completes the pattern. All working edges that may be required should be added to the pattern after-

wards. The quickest and simplest method of obtaining the shape of the hole required in the tank is to hold the pipe in position on the side of the tank and scribe round it.

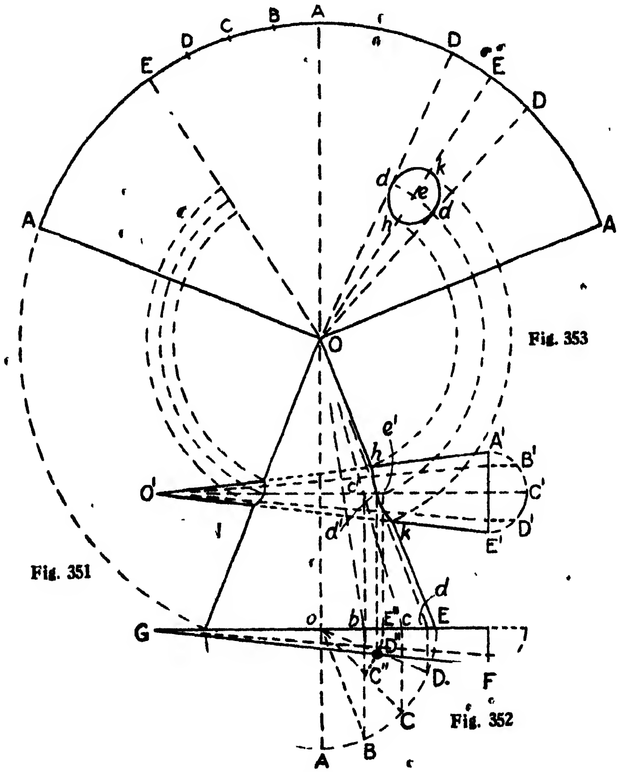
Development of Steel Converter.—Let *a g* A G (Fig. 348)



Figs. 348 to 350.—Development of Steel Converter.

represent an elevation of the steel converter for which patterns are required. It will be seen from the positions of the joints that two patterns are required—one for the *a d* A D portion of Fig. 348, and the other for the *d g* D G portion. Owing to the compound curvature of the body, it is not strictly developable, but notwithstanding this, serviceable patterns may be obtained by adopting the follow-

ing method of procedure. Produce G′a and G g (Fig. 348) to obtain the cone apex O. On the dotted line G′G (which



Figs. 351 to 353.—Patterns for Conical Penetration.

may be considered as the base of the cone) describe the dotted semicircle, divide it equally as at 1 2 3 4 5, and from these latter points draw dotted lines to the base of the cone, then unite them to O. Produce the line a G′ (Fig. 348)

below the base of the cone, and make G′A′ equal in length to the curved line G′A. Similarly, produce the line $b\,b'$, and make b'B′ equal in length to the curved line b'B. The line c'C′ is also obtained in like manner. Now draw a series of lines, parallel with the base of the cone, from B′C′DEFG$bcdefg$ (Fig. 348) in order to obtain a series of points on the left side of the cone, as indicated. To draw Fig. 349, a pattern for the adAD portion of Fig. 348, use O (Fig. 348) as centre, and describe a series of dotted arcs from the left side of Fig. 348, as illustrated. Now make G123 (Fig. 349) equal to G′123 (Fig. 348), and through the points G123 (Fig. 349) draw a series of lines as indicated, converging at O. A curve drawn from A to D, passing from one arc to another in the space of one division, and another curve drawn from a to d, similarly, will now complete the pattern.

Working edges for jointing, etc., must be added to the pattern where required; and in this connection it should be remembered that a curved allowance should be added on each side of the pattern (as shown by the dotted curves) in order to compensate for the "shrinkage" of the metal due to the hollowing of a compound surface. A pattern for the dgDG portion of Fig. 348 is illustrated by Fig. 350, and may be obtained by adopting the same method of procedure as that employed in the case of Fig. 349. The illustrations have been made practically self-explanatory to a student of pattern drawing. The letter references in all three illustrations are marked coincidently, and a little careful study will enable the reader to realise the whole method of development. Thus, the lines aA, bB, cC, and dD (Fig. 348), become aA, bB, cC, and dD in the pattern (Fig. 349), and so on.

Pattern for Conical Penetration.—Let Fig. 351 repre-

sent an elevation of the conical penetration, and Fig. 352 a half plan. Before the pattern can be drawn it will be necessary to obtain the correct shapes of both junction curves where the smaller cone intersects the larger one. But as this involves a rather lengthy explanation, only one point is here dealt with to illustrate the method of procedure. Other points on the junction lines may, of course, be obtained similarly. To obtain, then, the central point d' (Fig. 351) on the junction line, first draw a semicircle on the line A′E′, divide it equally, as at B′, C′, and D′, then draw short dotted lines from these latter points to the base line A′E′, and at right angles with it, and from thence to the apex O′. Similarly, divide A E (Fig. 352) equally, as at B, C, and D, and from these latter points draw the dotted lines to give b, c, and d on the base line of the larger cone. Join b, c, and d to the apex O (Fig. 351), and B, C, and D (Fig. 352) to the centre of the plan, as indicated. From c' (Fig. 351) a point of intersection between C′O′ and c O, draw the vertical dotted line to give C″ in plan. Similarly, from the intersection point d'_1 (Fig. 351), which is the junction between C′O′ and d O, let fall the dotted line to give D″ in plan. Then from e' (Fig. 351), the junction between C′O′ and E O, let fall the dotted perpendicular to give E″. A dotted curve is then drawn through C″ D″ E″ (Fig. 352), and on the point of intersection D″ between this curve and F G (Fig. 352) erect the dotted vertical line to give a point which is practically in the same place as d' (Fig. 351). Join $h\,d'$ and k to give the junction curve. To strike out the pattern (Fig. 353) use O as centre, and the slant depth of the cone as radius, in the usual way. Make A B C D E (Fig. 353) equal to A B C D E, then make E A (Fig. 353) equal to A B C D E (Fig. 353), and so on for the other half of the pattern, as illustrated. To obtain the shape of the larger

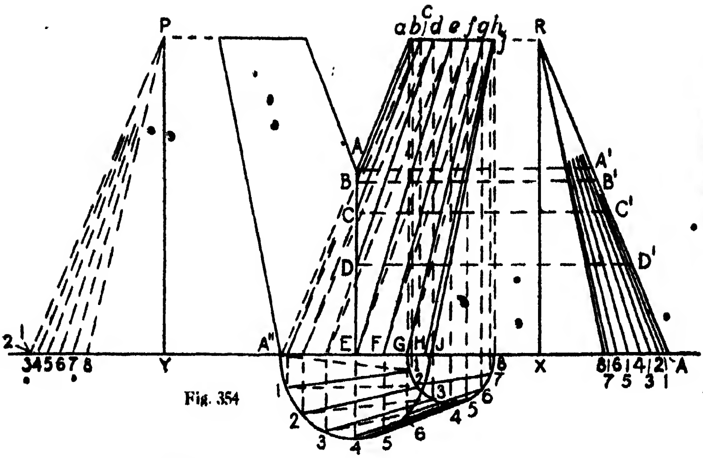


Fig. 354

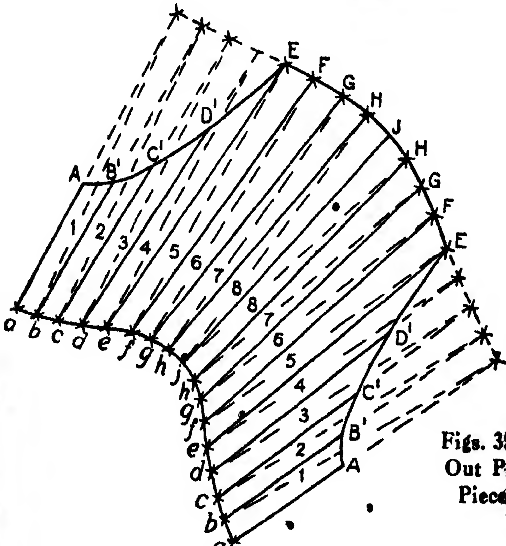


Fig. 355

Figs. 354 and 355.—Setting Out Pattern for Breeches Piece by Triangulation.

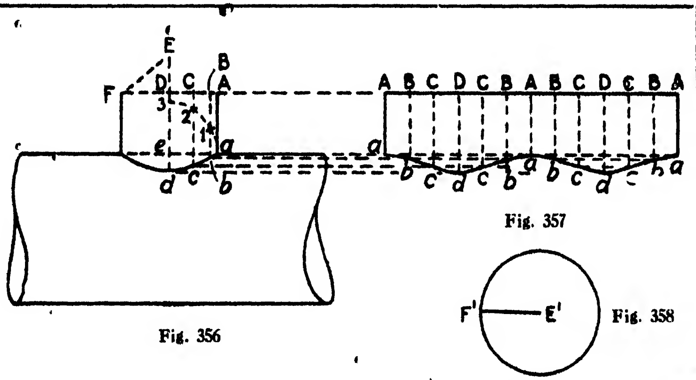
hole of interpenetration use O as centre and draw dotted arcs from h, e', and k (Fig. 351) to give h, e, and k (Fig. 353). Make E D on the outer arc (Fig. 353) equal to E D (Fig. 352). Unite D and D (Fig. 353) to the apex O to give $d\,d$, the width of the hole. A curve drawn through h, d, k, and d to h (Fig. 353) gives the shape required. The smaller hole may be obtained in a similar manner. It should be borne in mind that more points must be located on the junction line (Fig. 351) if greater accuracy is required.

Setting Out Pattern for Breeches Piece by Triangulation.—Let Fig. 354 represent an elevation of the breeches piece for which a pattern is required. When setting out the design, always endeavour to get the upright height A E of the junction line approximately equal to the diameter of the main pipe. This enables the breeches piece to be developed and assembled without the distortion of shape that is otherwise liable to occur. In the event of both legs being unequal, a pattern for each will be required, which must be separately marked out; but where both legs are equal, one pattern will suffice. In any case, the correctly proportioned elevation (showing, of course, the requisite diameters of the branch pipes) must first be drawn, as in Fig. 354. Now draw a half plan of one of the branch members as follows: Describe two semicircles, as illustrated, one to represent one-half of the main pipe, and the other one-half of the branch pipe. Divide these equally as at 1, 2, 3, 4, 5, etc.; join 11, 22, 33, 44, 55, etc., together with straight lines, and also draw the dotted diagonals A″1, 12, 23, 34, etc., as indicated. From the points on the larger semicircle draw a series of dotted lines to the base line, and from the points on the smaller semicircle draw another series to the top of the branch; then join those points at the top of the branch to those on the

base line so as to obtain A, B, C, D, E, F, G, H, and J, and *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, and *j*. The true lengths of these lines may be obtained by making X, 123456, etc., equal to the plan lines 11, 22, 33, 44, 55, 66, etc., and then joining the former to R. Similarly, the true lengths of the diagonals shown in plan may be obtained by marking off their respective lengths from Y, as at 1, 2, 3, 4, 5, 6, 7, and 8, and then joining the latter points to P. Thus P1 would be the true length of the first diagonal which joins A″ to 1 in the plan, and so on. Projectors are drawn from A, B, C, and D to give A′, B′, C′, and D′ as indicated. The pattern (Fig. 355) can now be built up of a series of triangles as follows: Make J*j* (Fig. 355) equal to J*j* (Fig. 354). With compasses set to A″1 (Fig. 354) describe an arc, using J (Fig. 355) as centre. With compasses set to one of the divisions of the small semicircle, say 56 (Fig. 354), describe an arc, using *j* (Fig. 355) as centre. Then make *j*H (Fig. 355) equal to the true length P8 (Fig. 354). Similarly make H*h* (Fig. 355) equal to the true length R7 (Fig. 354). The same method of procedure is adopted to obtain all the other points. A*a*, B′*b*, C′*c*, and D′*d* (Fig. 355) are made equal to RA′, RB′, RC′ and RD′ (Fig. 354) respectively. Curves drawn through the points thus obtained complete the pattern, but working edges must be added afterwards.

Development of Dome.—First draw an elevation of the dome on the boiler, as in Fig. 356. The dome can best be made in two parts—the lower cylindrical part, a pattern for which is shown by Fig. 357, and the spherical-shaped top, a pattern for which is represented by Fig. 358. With *e* (Fig. 356) as centre, draw the quarter circle *a*3, divide it equally as at 12, and through these points draw vertical lines to give B*b* and C*c*. Set the compasses to one of the divisions of the quarter circle, say 12 (Fig. 356),

then step off twelve distances along the line A A (Fig. 357). From these points B, C, D, etc. (Fig. 357), drop the vertical dotted lines, as illustrated, and project a series of dotted lines from *a*, *b*, *c*, and *d* (Fig. 356) to meet the vertical lines in the points *a*, *b*, *c*, and *d* (Fig. 357). A curve drawn through these latter points, passing from one line to another in the space of one division, completes the pattern. Working edges for seams and flanges, if required, must be added



Figs. 356 to 358.—Development of Dome.

to the pattern. A pattern for the top is a simple disc (Fig. 358), whose radius E′F′ equals E F (Fig. 356).

Pattern for Conical End of Cylinder.—Let Fig. 359 represent an elevation of the conical-ended cylinder. A pattern for the conical ends may be drawn as follows: With C as centre, describe the quadrant B 4, and divide it equally as at 1, 2, and 3. Now with A (Fig. 360) as centre, and radius equal to A B (Fig. 359), describe the arc, as illustrated. Make B, 1, 2, 3, 4 (Fig. 360) equal to B 1, 2, 3, 4 (Fig. 359); make 4B″ (Fig. 360) equal to 4, B; then make

B, 4′, B′ (Fig. 360) equal to B, 4, B″. Unite B′ and B″ to A (Fig. 360) to complete the pattern. Working edges for seams, etc., must be added to the pattern as required. This article would be made in three pieces—the plain cylinder and the two conical ends.

Pattern for Unequal Tapering Centre Tee.—Let A′ *a*′, C *c*, and A *a* (Fig. 361) represent a side elevation of the

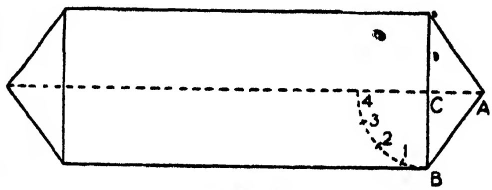


Fig. 359

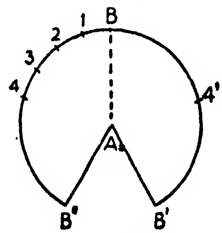


Fig. 360

Figs. 359 and 360.—Pattern for Conical End of Cylinder.

centre piece for which a pattern is required. First produce A′ *a*′ and A *a* in order to obtain *g* and 4 (Fig. 361), then let *g h* 4 *d e f* represent a half plan. An end elevation is shown by Fig. 362, and it will be seen on referring to Figs. 361 and 362 that the taper or overhang occurs in opposite directions and the centre-piece also tapers from oval to round, making the problem somewhat complicated. First erect a perpen-

dicular on 2 (Fig. 361) to obtain B b 2′, then join 2′ to C, as indicated by the dotted line. Now divide the arc 234 equally as at 3 and unite f3; make f3′ equal to f3, and

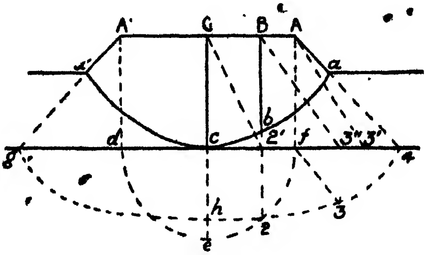


Fig. 361

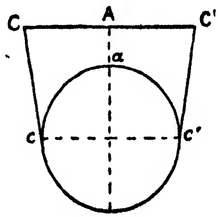


Fig. 362

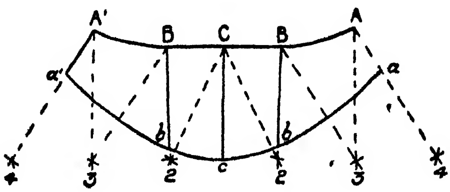
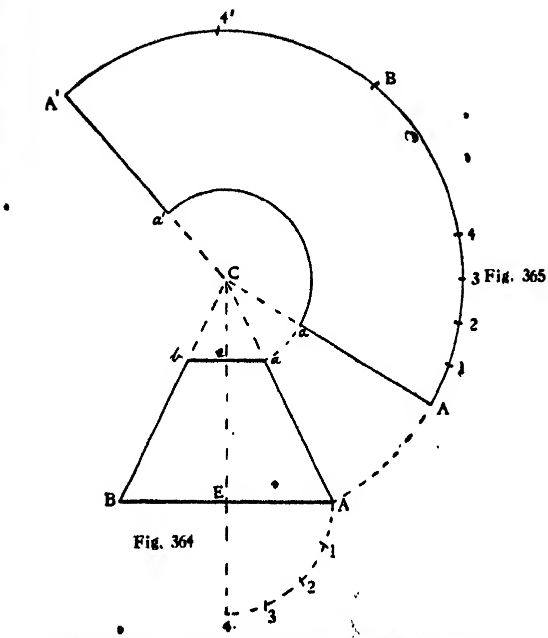


Fig. 363

Figs. 361 to 363.—Setting Out Pattern for Tapering Centre Tee.

join 3′ to A. Make 2′3″ equal to 23 and unite 3″ to B. To draw the pattern (Fig. 363) make C c equal to C c (Fig. 362); make c2 (Fig. 363) equal to h2 (Fig. 361) and CB (Fig. 363)

equal to *e* 2 (Fig. 361). Make C 2 and 2 *b* B (Fig. 363) equal respectively to C 2′ and 2′ *b* B (Fig. 361). Make B A (Fig. 363) equal to 2 *f* (Fig. 361) and 2 3 (Fig. 363) equal to 2 3 (Fig. 361). Now make B 3 (Fig. 363) equal to B 3″ (Fig. 361) and

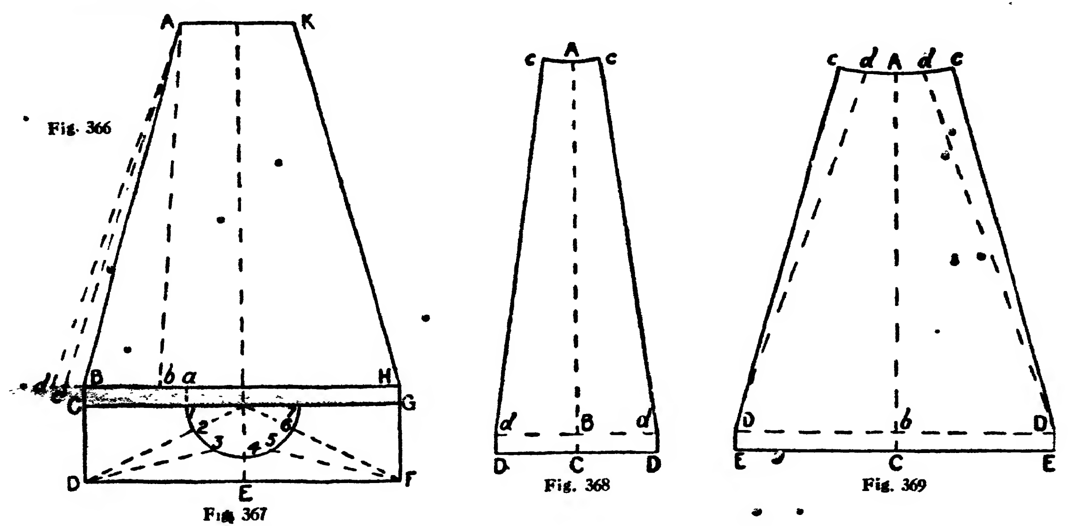


Figs. 364 and 365.—Setting Out Pattern for Conical Vertical Boiler.

3 A (Fig. 363) equal to A 3′ (Fig. 361). Make 3 4 (Fig. 363) equal to 3 4 (Fig. 361) and A *a* 4 (Fig. 363) equal to A *a* 4 (Fig. 361). Join the points thus obtained, and as illustrated, in order to obtain the pattern shown by Fig. 363, which is one-half of the pattern required. The other half is identical, and can be marked off Fig. 363.

Setting Out Pattern for Conical Vertical Boiler.—Assume the dimensions given are as follows: Circumference of smaller diameter 2 ft. 3 in., circumference of larger diameter 5 ft. 10 in., upright height 14 in. The smaller diameter will thus be 8.6 in. (approx.), the larger diameter 22.3 in. (approx.), and from these dimensions an elevation can now be drawn. Let Fig. 364 therefore represent the elevation showing *b a* = 8.6 in., B A = 22.3 in., and *c* E = 14 in. First produce A *a* and B *b* to obtain C, the apex of the cone; then with E as centre, draw the arc A 4 (a quadrant) and divide it equally at 1 2 3 as illustrated. Now with C as centre, draw arcs from A and *a*, as indicated, and make A 1 2 3 4 (Fig. 365) equal to A 1 2 3 4 (Fig. 364). Open the compasses to A 4 (Fig. 365), then beginning at 4, step off B 4′ A′ (Fig. 365). Join A′C and A C to give A *a* and A′ *a*′, the pattern required. All working edges must be added to pattern as, and where, required.

Setting Out Patterns for Hood Tapering from Rectangular to Round.—Let A B C K H G (Fig. 366) represent an elevation, and C D E F G 1 4 7 (Fig. 367) a half plan of the hood for which patterns are required. There will be two patterns, one for the sides and the other for the ends, while the seams will occur along the lines D 2 and F 6 (Fig. 367). First divide the semicircle (shown in plan) into a number of equal divisions as at 1,2,3,4,5,6, and 7 (Fig. 367), and then draw the dotted lines from the corners D and F as indicated. Before the patterns can be set out, the true elevational lengths of the plan lines D 2, D 3, and E 4 must first be obtained as follows: From *a* along the horizontal line B H (Fig. 366) make *a b* equal to E 4 (Fig. 367); make *a c* and *a d* (Fig. 366) equal to D 2 and D 3 (Fig. 367); and unite the points thus obtained to A (Fig. 366) by means of the dotted lines, as illustrated. The plan lines F 5 and F 6 (Fig. 367)

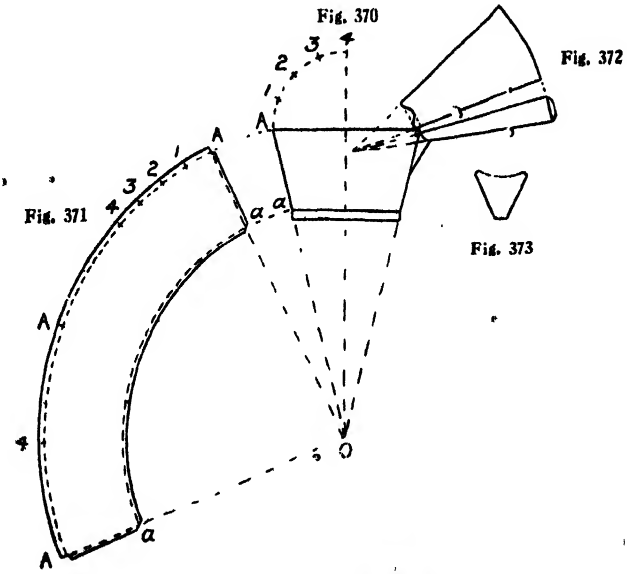


Figs. 366 to 369.—Setting Out Patterns for Hood Tapering from Rectangular to Round.

can be ignored, since they are equal to D 2 and D 3, because the hood tapers equally. Beginning now with the end pattern (Fig. 368), make the dotted central vertical line ABC equal to ABC (Fig. 366); make B*d* and CD on each side of the central line (Fig. 368) equal to CD (Fig. 367). Make A*c* (Fig. 368), on each side of the central line, equal to 1 2 (Fig. 367); then make *dc* on each side of the central line (Fig. 368) equal to the length of the dotted line A*c* (Fig. 366). A small curve drawn from *c* to *c* (Fig. 368), passing through the point A, completes the pattern. To draw the pattern (Fig. 369) for the sides, make A*b* (Fig. 369) equal to A*b* (Fig. 366); make *b*C (Fig. 369) equal to BC (Fig. 366); make *b*D and CE (Fig. 369), on each side of the central line, equal to DE (Fig. 367). Make A*d* (Fig. 369), on each side of the central line, equal to 3 4 (Fig. 367); make D*d* (Fig. 369), on each side of the central line, equal to the length of the dotted line A*d* (Fig. 366); make *dc* (Fig. 369), on each side of the central line, equal to A*d* (Fig. 369); then make D*c*, on each side of the central line, equal to the length of the dotted line A*c* (Fig. 366). A curve drawn from *c* to *c* (Fig. 369), passing through the points *d*, A, and *d*, completes the pattern. Allowances for all working edges must be added to the patterns as, and where, required. It should be remembered that setting out patterns by the triangulation method (which is the only practicable method in some cases) always appears to be more involved than it really is. This is due to the necessity of first obtaining the true elevational lengths of certain plan lines, and then transferring them, together with certain distances, in order to build up the pattern by degrees.

Setting Out Patterns for Taper Lading-can.—Let Fig. 370 represent the lading-can for which patterns are required. First produce the sides of Fig. 370, as shown by

the dotted lines, in order to obtain o, the apex of the cone; then draw the dotted quarter circle A 4 and divide equally at 1, 2, and 3. With o (Fig. 370) as centre, draw the dotted arcs A A and *a a* (Fig. 371) as indicated, and from A (Fig. 371) step off 1, 2, 3 and 4, making the distances equal to



Figs. 370 to 373.—Setting Out Patterns for Taper Lading-can.

A, 1, 2, 3, and 4 (Fig. 370). Open the compasses to A 4 (Fig. 371), then beginning at 4 (Fig. 371) step off at A 4 A. Unite A *a* on each side of the pattern to o, as illustrated. Working edges are now added to the pattern as follows: A wiring-edge round the outer arc A A; an edge for a knocked-up bottom round the inner arc *a a*; and edges on each side

A *a* for a grooved seam. If a simple lap seam is preferred, then one edge along one side A *a* may be dispensed with; and if a capped-on, instead of a knocked-up bottom, be decided on for simplicity's sake, the edge round the inner arc *a a* may be cut out. A pattern for the handle is shown by Fig. 372, where the method of setting out is also illustrated, so as to render it practically self-explanatory. Fig. 373 represents a pattern for the support which is fixed under the handle, and also to the lading-can side. No pattern is shown for the rim, or foot, of the lading-can, since a ring of narrow tinned hoop-iron will suffice. In the absence of proper tools, a lap seam and a capped-on bottom should be decided on. The wiring edge may be set off by gradually malleting it over, say, the square edge of the end of a domestic sad-iron, and if the iron can be firmly fixed in a vice, or otherwise, the edge can be wired on it. A makeshift way of turning the lading-can to shape would be to bend it, say, round a piece of down spouting previously fixed in a horizontal position; or a short wooden pole could be made to serve the purpose. The handle and boss could both be shaped over a short-length of iron gas-piping, which should preferably be fixed in a vice. The bottom could be edged over the end of the down spouting previously mentioned.

Setting Out Patterns for Irregular Tapering Bend. —Let Fig. 374 represent a plan of the top of the bend, and Fig. 375 a side elevation. The curves of the side elevation may be obtained as follows: Having fixed the points *c* C *c′* and *e* E *e′* according to the required lay-out, produce C *c′* and *e e′* to obtain O, then draw X Y at right angles with O *c*. The respective centres for the outer, centre and inner arcs will then occur on the line X Y, as shown. The points 1 2 *d* on both the outer and inner arcs are fixed in order to facili-

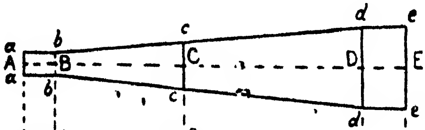


Fig. 374

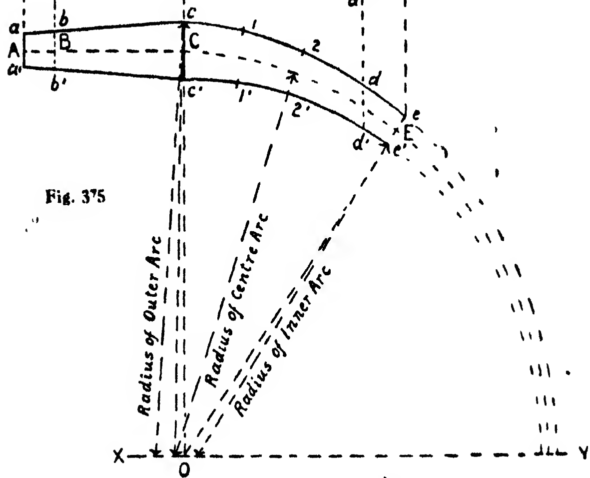


Fig. 375

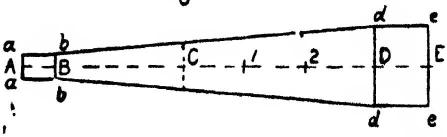


Fig. 376

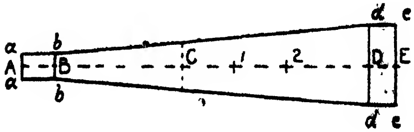


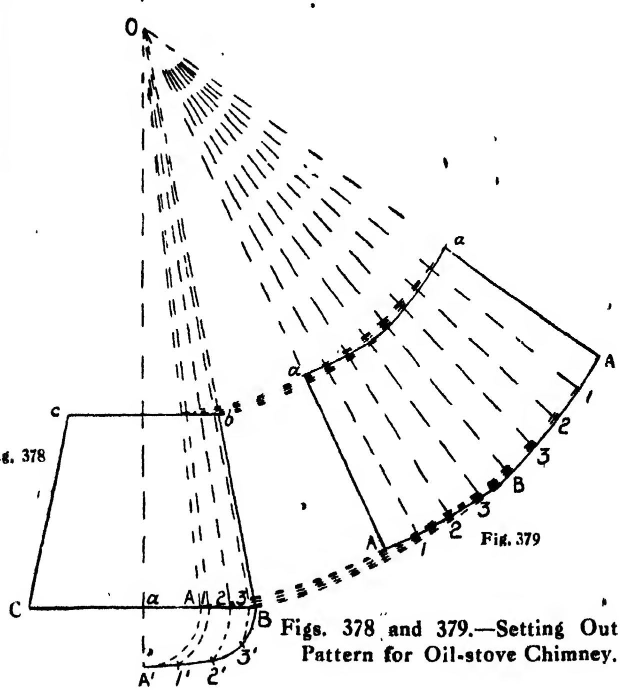
Fig. 377

Figs. 374 to 377.—Setting Out Patterns for Irregular Tapering Bend.

tate the transference of the respective lengths of these arcs later when setting out the patterns. The correct pattern for the top is illustrated by Fig. 376. First set off along the central dotted line A B C 1 2 D E, making them equal to *a b c* 1 2 *d e* (Fig. 375). Make *a a*, *b b*, *d d*, and *e e* (Fig. 376) equal respectively to *a a*, *b'b*, *d d*, and *e e* (Fig. 374), then join up the points with straight lines as indicated. A pattern for the bottom (which is not quite the same as that for the top because of the shape of the bend at *e* E *e'* in the side elevation) is shown at Fig. 377. The distances A B C 1 2 D E, along the central dotted line, are made equal to the distances *a' b' c'* 1' 2' *d' e'* (Fig. 375). Make *a a*, *b b*, *d d*, and *e e* (Fig. 377) equal to *a a*, *b b*, *d d*, and *e e* (Fig. 374), then join up the points with straight lines. The shape of the side elevation itself will, for all practical purposes, serve as a pattern for both sides. All working edges that may be required should be added to the patterns.

Setting Out Pattern for Oil-stove Chimney.—Let *c b* C B (Fig. 378) represent an elevation, and *a* A' 1' 2' 3' B a quarter plan of the chimney for which a pattern is required. First divide the arc A' B equally as at 1', 2', and 3', then with *a* as centre describe the dotted arcs from A', 1', 2', and 3' in order to obtain A, 1, 2, 3 on the base line. Now produce C *c* and B *b* to obtain O, the apex of the cone; then draw the dotted lines from A, 1, 2, 3 to O, as indicated. To draw the pattern (Fig. 379) use O as centre, and describe a series of dotted arcs from A, 1, 2, 3, and B (Fig. 378), and also from those points where the dotted lines cut the top of the elevation as illustrated. Set the compasses to one of the divisions of the quarter plan (A' 1', for example), then beginning at A (Fig. 379) step off 1, 2, 3, B, 3, 2, 1, and A, taking care to step from one arc to another in the space of one division. Now draw a series of dotted lines from

these latter points to, o, as shown in Fig. 379. A line drawn from *a* to *a*, passing from one arc to another in the space of one division, and another line drawn similarly from A to A, completes one-half of the pattern required.



Figs. 378 and 379.—Setting Out Pattern for Oil-stove Chimney.

The other half is identical in every respect, and may be obtained by simply repeating the method of working just described.

As already explained more than once, all working edges must be added to the pattern as and where required.

Setting Out Patterns for Copper Tee.—Let Fig. 380

represent an elevation of the T-piece for which patterns are required. First find the junction line *a b c d e f g* (Fig. 380), as follows: Describe a semicircle on the line A G (Fig. 380); divide it equally as at 1, 2, 3, 4, and 5, and from

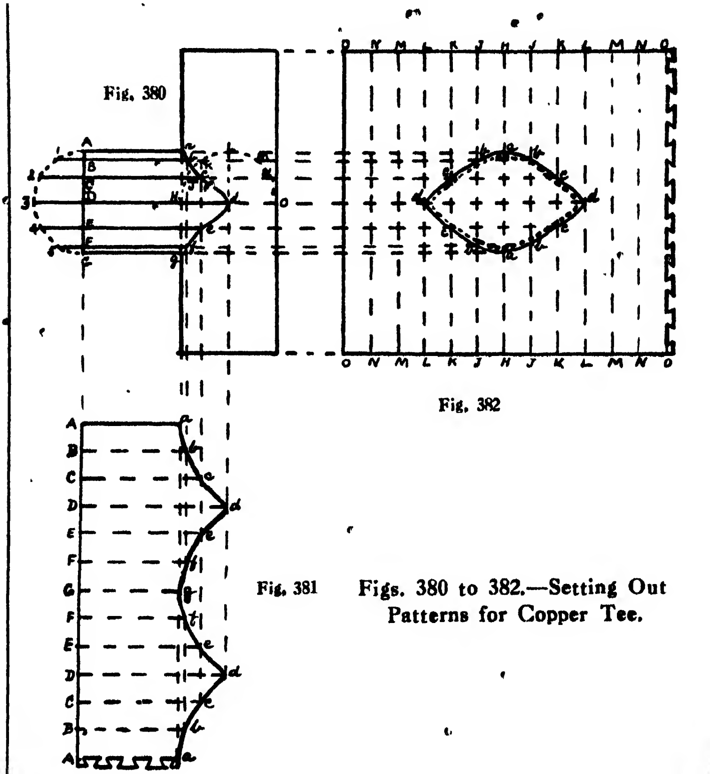


Fig. 380

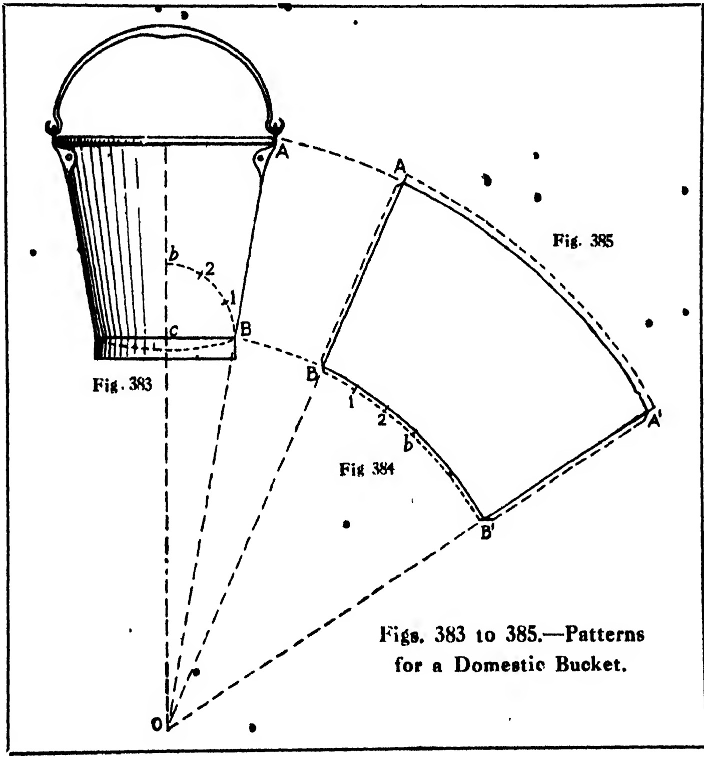
Fig. 381

Fig. 382

Figs. 380 to 382.—Setting Out Patterns for Copper Tee.

the points of division draw lines parallel with A *a* (Fig. 380), as indicated. Now with *d* (Fig. 380) as centre, draw the dotted semicircle on the line H O, divide it equally as at J, K, L, M, and N, and then draw the dotted vertical lines from those points where the parallel lines touch the semi-

circle. Thus, the parallel line B *b* touches the semicircle in the point K, therefore from K draw the dotted vertical in order to obtain the points *c* and *e* on the junction line. Similarly the parallel C *c* touches the semicircle in the



Figs. 383 to 385.—Patterns for a Domestic Bucket.

point J, therefore draw the dotted vertical through J, in order to obtain *b* and *f* on the junction line. The shape of this junction line varies as the relative sizes of the main pipe and branch pipe vary. Hence, a small branch on a relatively larger main would not require to be scalloped so much as the present example; but where the main and

the branch pipes are of the same diameter the illustrations show the correct geometrical construction. The foregoing is mentioned because some workmen fail to scallop the branch pipe to the requisite depth—particularly on an equal tee—with the result that the true cylindrical shape of either the branch or the main pipe inevitably suffers distortion in order to make the pipes fit. A pattern for the branch pipe is shown by Fig. 381. Set the compasses to 12 (one of the divisions of the dotted semicircle in Fig. 380), and then step off twelve such distances, as at B, C, D, E, F, and G (Fig. 381). From these latter points draw a series of dotted lines, as illustrated, and then project another series of dotted lines from *a*, *b*, *c*, *d*, *e*, *f*, and *g* on the junction line (Fig. 380) to cut the former series in *a*, *b*, *c*, *d*, *e*, *f*, and *g* (Fig. 381). A curve drawn to pass through the points of division, as indicated, completes the pattern. A pattern for the main pipe is shown by Fig. 382, where the distances from O to O represent twice the number of distances that are contained in the semicircle HLO (Fig. 380). A series of dotted lines is drawn from the points of division to cut another series drawn from the points *a*, *b*, *c*, *d*, *e*, *f*, and *g* on the junction line (Fig. 380), in order to give *a*, *b*, *c*, and *d* (Fig. 382). A curve drawn through these latter points gives the shape of the hole of penetration; and the inner dotted curve represents allowance for an edge which may be flanged outwardly after the pipe is made, for the branch to fit over. The seams of both the main and branch pipes should be dovetailed and brazed, and additional allowances are shown on both pipes for this purpose. There is no need to draw all the lines here shown when setting out the patterns. These are inserted to render the method of working abundantly clear. Only the essential points need to be fixed on the elevation as well as on the patterns.

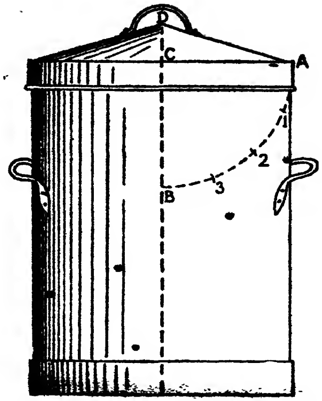


Fig. 386.—Sanitary Dust-Bin.

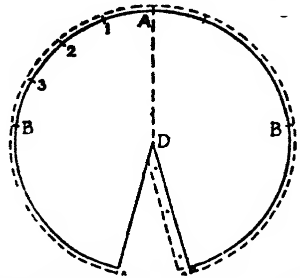


Fig. 389.—Pattern for Conical Top.

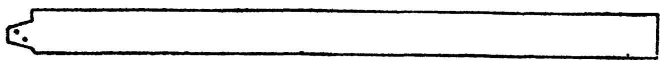


Fig. 388.—Pattern for Cover Rim.

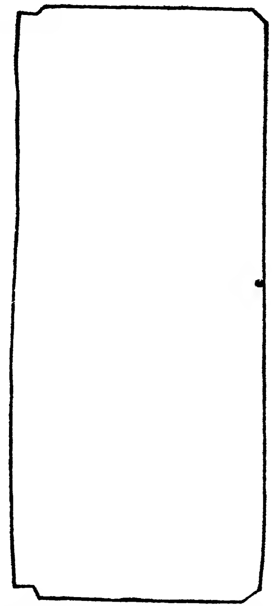


Fig. 387.—Pattern for Body.

Pattern for a Domestic Bucket.—An ordinary domestic bucket is shown by Fig. 383. The body is made in two halves, which are grooved together, and a pattern for one half is shown by Fig. 384.

To draw the pattern, first describe the quadrant B b (Fig. 383), and divide it equally as at 1 and 2. Produce the centre line of the bucket and also A B (Fig. 383) until they converge at O. With the latter point as centre, draw arcs from A and B (Fig. 383), as illustrated, then make B 1 2 b (Fig. 384) equal to B 1 2 b (Fig. 383). Make b B′ (Fig. 384) equal to B 1 2 b (Fig. 384) and unite B B′ to O, producing both lines in order to obtain A and A′ (Fig. 384). The dotted arc above A A′ (Fig. 384) represents a wiring edge; the dotted arc below B B′ represents a working edge for a "knocked-up" bottom seam; while the straight dotted lines parallel with A B and A′B′ represent working edges for grooved seams.

Both halves are passed through the rollers, being alternately bent in opposite directions in order to break the metal and thus prevent creases in the finished article. The side edges are bent in opposite directions for grooved seams, and the top wiring-edges are then bent slightly more than at right angles.

After grooving both halves together, the top edge is wired with No. 8 B.W.G. wire, preferably tinned, and then the body is bent to shape through the rollers and seamed. A small edge is next set off in an outward direction for the bottom seam. Both grooved seams are then soldered down inside.

The bottom is a hollowed disc, as may be seen by the dotted arc in Fig. 383. In the flat this disc is cut ¾ in. larger in diameter than that of the edged bottom of the body.

Miscellaneous Problems

Patterns for a Sanitary Dust-bin.—A receptacle for domestic rubbish is shown by Fig. 386. By making the top of the cover slightly conical, much time and labour are saved that would otherwise be spent in hollowing.

A pattern for the body is shown by Fig. 387, which is notched for a wiring edge, a grooved seam, and a knocked-up bottom, the working edges for which are allowed on the pattern.

A pattern for the bottom is not shown, since this is but a disc of metal about $\frac{3}{8}$ in. larger in diameter than that of the edged body.

A pattern for the rim of the cover is given, with the necessary working edges, by Fig. 388.

A pattern for the conical top of the cover is illustrated (together with the necessary working edges) by Fig. 389, and it may be set out as follows: On A C (Fig. 386) describe the quadrant A B, and divide it equally as at 1, 2, and 3. With D (Fig. 389) as centre, and D A (Fig. 386) as radius, describe the arc A A A (Fig. 389). Make A 1 2 3 B (Fig. 389) equal to A 1 2 3 B (Fig. 386); make B A (Fig. 389) equal to A 1 2 3 B (Fig. 389), and similarly obtain B and A on the right side of the pattern. Join A A to D (Fig. 389), then add the lap edge showing the three rivet holes, and also the dotted edge round the arc to complete the pattern. It will facilitate the shaping if a small hole be punched in D (Fig. 389).

CHAPTER XIII

Sheet-metal Seams or Joints

The accompanying illustrations represent a selection of the principal joints used in sheet-metal work, and the drawings are purposely enlarged in order to render the formation of the various joints clearer than they would otherwise be. Fig. 390 represents the simplest joint (the lap-joint) known to the sheet-metal worker. A soldered joint of this description varies in width of lap from $\frac{1}{4}$ in. in light work to $\frac{3}{8}$ in. and more in heavy work. For very heavy work the lap-joint is riveted as shown by Fig. 391. The joint represented by Fig. 392 is essentially the same as Fig. 390, except that the lap is sunk, as indicated, in order that the top of the joint may be flush. Fig. 393 shows a grooved joint before being grooved, and Fig. 394 shows the same joint after being grooved. Fig. 395 represents the same joint essentially, but it is sunk in an opposite direction. Its use may be explained by taking the case of a cylinder, for example. When the thickness of the grooved seam is objectionable inside the cylinder, or, what amounts to the same thing, when it is not objectionable outside the cylinder, the seam is made as at Fig. 394. When, however, it is objectionable outside the cylinder, then it is made as at Fig. 395. The seam shown by Fig. 396 is made when the metal is too thin or too thick to groove in the usual way. This kind of joint is useful when making gauze cylinders. Fig. 397 represents a simple capped-on bottom joint, which is usually soldered round. It is

Fig. 390.—Lap-joint.

Fig. 391.—Riveted Lap-joint.

Fig. 392.—Sunk Lap-joint.

Fig. 393.—Grooved Joint before being Grooved.

Fig. 394.—Grooved Joint after Grooving.

Fig. 395.—Sunk Grooved Joint.

Fig. 396.—Seam for Thin Metal.

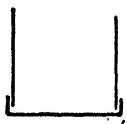


Fig. 397.—Capped on Joint.

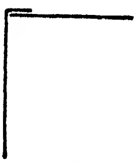


Fig. 400

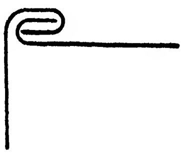


Fig 402

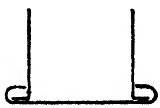


Fig. 398.—Paned-down Joint.

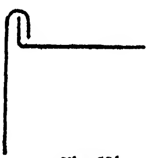


Fig. 401

Figs. 400 to 402.—Box Joints.

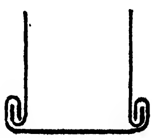


Fig. 399.—Curled Joint.

not a very strong joint, but for light tin-ware, and especially where such tinware is not expected to be subject to rough usage, it is fairly serviceable. Fig. 398 shows a paned-down joint, which is a step towards making the knocked-up joint represented by Fig. 399. This latter joint is far superior to Fig. 397, and it is extensively used for attaching bottoms to the various kinds of sheet-metal vessels in common use. Where it is impracticable to employ the joint shown by Fig. 399, and where a strong joint is required, then Fig. 398 is the next best to use—providing that the projecting edge is not objectionable. Figs. 400, 401, and 402 are essentially the same joints as Figs. 397, 398, and 399, with the exception that they are intended for use on flat surfaces, such as boxes, etc., instead of in connection with rounded vessels. The corner of a square box could have a joint such as that shown by Fig. 400, but it would require either to be soldered or riveted; riveting, of course, would considerably strengthen it. A more extensively used joint, however, requiring neither soldering nor riveting, is that shown by Fig. 402. Another corner joint is represented by Fig. 403. In this case, it will be observed that the thickness of the seam is sunk, so that the outside of the corner will be flush. This joint is really a modification of that shown by Fig. 395. A joint commonly used for fastening the top of a hollowed cover to its rim is illustrated by Fig. 404. The paned-down joint, Fig. 405, can be utilised for connecting two cylindrical bodies together. Fig. 406 shows a stage in the formation of Fig. 407, which represents a knocked-up joint connecting a body, a bottom, and a foot, or rim, together as in the case of a coal box. Fig. 406 also represents a joint which is used on a vegetable steamer to connect the body, the perforated bottom, and the rim to-

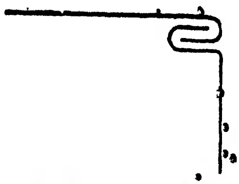


Fig. 403.—Corner Joint.

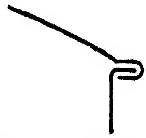


Fig. 404.—Rim Joint.

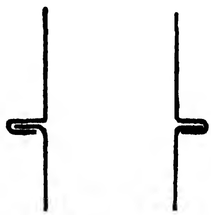


Fig. 405.—Another form of Paned-down Joint.

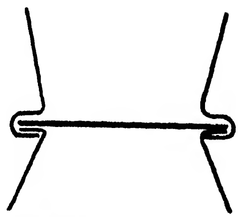


Fig. 406.—Knocked-up Joint: First Operation.

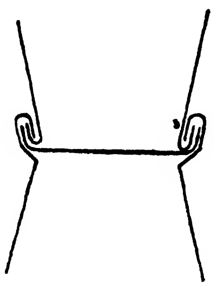


Fig. 407.—Finished Knocked-up Joint.

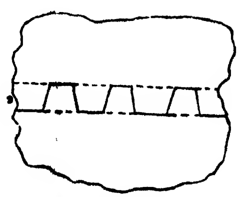


Fig. 408.—Brazed Joint.

gether, although in the case of a steamer the rim would not taper outwardly as in the illustration. Figs. 408 and 409 represent two kinds of brazing joints, the former of which is by far the easier to make. Fig. 409 is only employed for thick metal where both sides are required

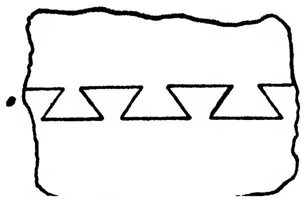


Fig. 409.—Another form of Brazed Joint.

perfectly flat. It is a somewhat troublesome joint to make, involving an amount of labour out of all proportion to its utility; and it is really doubtful if it is any better than a simple lap-joint whose laps have been previously thinned so that both together will equal the original thickness of the metal. The common butt-joint is not shown, since this is simply two edges butting together preparatory to brazing them together.

CHAPTER XIV

Planishing Sheet Metal

The planishing of sheet metal is an art which often presents unnecessary difficulties to many workmen solely because they have not sufficiently mastered the principles involved, and as those connected with pattern drawing often have to supervise the actual working of the metal, it has been considered desirable to devote space to matters not strictly within the scope of the title of this book. Thus through the non-observance of a few simple rules based on practical experience, a congenial task is too often converted into a tedious and laborious process, necessitating the maximum expenditure of time and energy in order to accomplish indifferent results. Some workers still regard planishing as a more or less mysterious process, which gives results that cannot be anticipated, while others regard it as a matter of experiment, and are correspondingly relieved when satisfactory results are unexpectedly obtained.

Planishing is resorted to either to harden the metal by closing the grain, or to remove a buckled condition which has originated during some process of manipulation; and probably in the many manipulative processes which the metal is called on to undergo, no blow is fraught with such consequences for good or evil as that which is struck in the process of planishing.

As planishing causes superficial expansion of the metal at the expense of its thickness in the immediate vicinity of the blow, it is essential that the workman should have

a clear idea of what blows are necessary, and exactly where they are required before delivering them. A blow wrongly struck, or delivered in the wrong place, necessitates quite half a dozen other blows to correct it, hence the worker should cultivate a habit of rapidly calculating the probable effect of each prospective blow. No blow should be struck unless to accomplish some definite purpose that has been mentally estimated beforehand during the process of planishing; and this is of the utmost importance when planishing to remove a buckled condition of the metal.

Both anvil and hammer should be clean and well polished before attempting to planish anything, and the former should be sufficiently low to enable the worker to control his work properly. To planish on a high anvil is a waste of energy. When standing, the surface of the anvil should not be higher than the top of the thigh; but if a sitting posture is preferred, then the anvil should be between the legs, and its surface not higher than a little above the knees. The hammer should be held with the thumb resting on the top of the shaft, the better to control the blows, and the worker would do well to cultivate a "bouncing" style of hammering, this being by far the most effective method of obtaining the maximum result with the minimum amount of effort.

Some metals (particularly copper), after being subjected to annealing, require to be planished to close the grain of the metal, so as to harden it and thus increase its durability. Little difficulty, however, need be experienced in planishing to accomplish this object, since all that is required is a series of blows delivered uniformly all over the surface of the metal—preferably from the centre to the outer edges. Every blow should produce a spot; no two blows should be dealt in the same place, and the worker

should guard against an ill-delivered blow, which is likely to produce a "half moon."

Where a buckled condition of the metal requires treatment, much more thought and skill are necessary. In order to appreciate the kind of treatment required to remove a twist or buckle in a sheet of metal, it will be helpful first of all to consider what gives rise to the buckled condition. A disc of metal, for example, may be said to be buckled when from any cause its area is too small or too large to lie in one plane. Thus a disc may be "loose" in the centre and "tight" round the circumference, with the result that it cannot lie flat because the circumference unduly restricts its area, hence a bulge or buckle appears in the centre. Conversely, a disc may be "tight" in the centre and "loose" round its circumference, and this particular disc cannot lie in one plane because its central area is relatively too small for its circumference, hence the edges are unduly strained by the pull of the centre, with the result that they present a wavy appearance or a buckled condition. Every sheet-metalworker is constantly confronted with both these typical problems, in addition to others which may be regarded as a combination or modification of them. Now, if the cause of the buckled condition be thoroughly appreciated, the remedy becomes correspondingly obvious. Therefore, a buckled sheet should be examined to ascertain the cause of its condition before it is touched with the hammer.

Supposing, then, a disc is found to be "tight" round its circumference, and remembering that planishing causes superficial expansion, it will be readily understood that a few blows round the circumference will soon rectify matters. On the other hand, assuming that the centre is "tight," the blows should be delivered in the centre, and

should follow the lines of a spiral until the whole region of tightness has been brought under treatment. No more blows than are necessary should be struck, or a new buckle may be originated.

Occasionally it happens that one-half of a disc of metal (a semicircle) is tight while the corresponding half is loose. The remedy is to planish the tight half, preferably from the centre to the outer edges, until the buckle disappears. Instead of attempting to rectify the abnormal condition of the metal by treating one small portion of the surface at a time, it is better to treat the buckle as a whole, and by delivering a series of blows radially, the object in view is the more speedily accomplished.

A surface having a compound curvature (for example, a portion of a hemisphere) may be planished either with a flat hammer on a rounded head, or a slightly bullet-faced hammer on a flat anvil. In each case care should be exercised so that the blows are delivered only when the metal rests solidly on the head of the anvil, as the case may be. Surfaces of this description are usually planished to harden the metal by closing the grain, in contradistinction to planishing for the purpose of removing buckles, it being assumed that all buckles are removed during the manipulation of the metal to the required shape. A case of complicated buckling is where a sheet of metal presents a series of minor buckles which are due to the surface of the sheet being both tight and loose in a number of different places.

Where a pair of rolls is available it is advisable to roll the metal, meanwhile curling it in opposite directions, and then eventually rolling it straight, so as to unite the small buckles into a less number of larger ones.

In every case it is a matter of great importance that the buckled condition of a sheet of metal should always be cor-

rected so as to relieve undue stresses, which, if neglected, can only have but deleterious effects.

Sheet copper or brass, after being tinned, requires planishing to counteract the effects of the heat imparted to the metal during the process of tinning. When the metal has been tinned on one surface only, that surface should be next to the anvil during planishing.

In conclusion, it may be stated that the foregoing information embodies the results of a lengthy practical experience; and a careful study of the principles here outlined, together with a little practice, will soon enable the sheet-metal worker to gain both a theoretical and practical knowledge of planishing.

CHAPTER XV

Hints on Annealing Sheet Metals

ANNEALING is a simple process which is commonly employed to restore, and in some cases to increase, the malleability of a given metal. During manipulation, whether by hammering, rolling, pressing, or spinning, sheet metal becomes harder or less malleable. Sometimes the required shape can be obtained without resort to annealing, but when the metal becomes pronouncedly harder to work, and the operation is incomplete, it is always advisable to anneal the metal rather than risk fracturing it before completing the shaping operation.

It frequently happens that metal requires to be annealed two or three times before a given shape can be obtained. That is to say, it is first worked to a certain stage, then it is annealed, and afterwards worked to a further stage, when it may be necessary again to anneal it before finally obtaining the requisite shape. Thus the malleability of the metal is restored by the process of annealing after being almost destroyed by some manipulative process.

Malleability may be defined as that property of a metal which permits its surface to be expanded or extended without fracture. Gold is the most malleable metal, and the following are placed in proper sequence: Silver, aluminium, copper, tin, lead, zinc, iron, nickel.

Annealing is very advantageous when dealing with a metal of doubtful quality—as a matter of fact, the choice sometimes lies between annealing the metal or spoiling the

job. But it should not be inferred that only metal of doubtful quality requires annealing. Even the best-quality metal sometimes requires annealing, and this is specially the case when the manipulative process has closed the grain of the metal, thus making it hard and unworkable, except at the risk of fracture.

A series of conflicting strains and stresses are generated in a sheet of metal while it is being worked from one shape to another. The process of annealing opens the grain of the metal and thus relieves the strains and stresses, which would otherwise result in a rupture of the metal.

Iron.—Supposing, for example, it is desired to "set off" a fairly large flange on a comparatively small diameter iron-pipe, such as a stove-pipe. The flange, of course, would be "stretched off." That is to say, the hammer would be employed to stretch the metal which is to constitute the flange; and more stretching would be required round the outer circumference than would be required round the inner circle of the flange. But stretching hardens the metal considerably, since the grain of the metal is closed with every blow of the hammer; and unless the metal is annealed after a certain amount of stretching, the flange will probably split round its outer circumference. The metal therefore is brought to a red heat, and then it is allowed gradually to cool down. This simple annealing process has the effect of softening the iron, thus making it more malleable, besides rendering it easier to work, and this without risk of fracture. Whenever any doubt is entertained as to the necessity of annealing during a given operation, it is always better to avoid risk, since many a job has been spoiled through failure to take the simple precaution of annealing the metal before the final operation.

Copper.—As already stated, copper is naturally more malleable than iron, yet it often requires annealing. A peculiar characteristic of copper is that while it can be annealed in much the same way as can iron, it can also be annealed by raising it to a dull red heat and afterwards plunging it into cold water. By adopting the latter method of annealing, the waiting period is cut out, and work is thus expedited. It is difficult to state exactly at what stage a piece of metal should be annealed, but a safe guide in this connection is when it offers considerably more resistance to working than it did originally. It is a mistake to endeavour to work copper while it is hot. Iron can be worked much better while it is hot, but it would be ruinous to attempt to work copper in a similar manner—and this also applies to brass.

Brass.—What has already been stated with reference to copper applies, more or less, to brass, but a great deal depends on its composition. When a sheet of brass cannot be annealed by heating it first to a dull red heat and then plunging it immediately in cold water, it can invariably be annealed by heating it and allowing it gradually to cool down of its own accord. Care should be taken not to overheat any metal, otherwise it becomes brittle, and in some cases rotten. Some kinds of brass will crumble while in a red-hot state if touched with a hammer.

Zinc.—On account of the low-melting point of this metal, annealing, as commonly understood, is out of the question. Most metal-workers, however, have noticed that zinc can be more readily worked in summer than in winter. As a matter of fact, zinc is most malleable when at a temperature a little above that of boiling water. Instead, therefore, of attempting to anneal zinc, it is advisable where practicable to warm it in order to render it

more malleable. The same object may be attained by working it in a well-warmed shop.

Aluminium.—The metal requires less annealing than those previously mentioned, and this characteristic is decidedly advantageous in pressing and spinning operations. It is now possible to draw a cylinder whose depth is more than 75 per cent. of its diameter from a flat blank of aluminium in one operation. After a preliminary annealing, this metal will undergo seven or eight drawing operations, whereas iron or copper must be annealed after every two or three draws. Steel and brass often require annealing after every operation. The softest (annealed) aluminium is used for spinning. During the spinning operation the metal hardens, of course, under the tool, but not so readily as copper. This enables the metal to be spun to a given shape without annealing. In other words, starting with a soft sheet of metal an article can be spun, without subsequent annealing, to a dead hard finish. A lubricant, however, should always be used with aluminium. Kerosene is recommended for punch pressings and for shallow draw-press work, but a thicker lubricant, such as lard oil or a cheap grade vaseline, is better for deep drawing operations. The thicker lubricant is also more suitable for spinning operations.

Care should be exercised when annealing aluminium not to overheat the metal. The melting point of aluminium is 1210° F., which corresponds to a dull red heat. A suitable annealing temperature varies from 750° to 850° F. A faint red heat corresponds to a temperature just under 1,000° F., from which it may be gathered that it is unwise to attempt to make aluminium red hot during the process of annealing.

CHAPTER XVI

Useful Data for Sheet-metal Workers

THE CIRCLE.

CIRCUMFERENCE = diameter multiplied by 3.1416, or $3\frac{1}{7}$.

Diameter = circumference divided by 3.1416, or $3\frac{1}{7}$.

Area = $\begin{cases} \text{square of diameter multiplied by .7854.} \\ \text{square of radius multiplied by 3.1416, or } 3\frac{1}{7}. \\ \text{square of circumference multiplied by .07958.} \end{cases}$

THE SPHERE.

Volume = cube of diameter multiplied by .5236.

Surface = square of diameter multiplied by 3.1416, or $3\frac{1}{7}$.

THE CONE, OR PYRAMID.

Volume = $\frac{1}{3}$ of base area multiplied by perpendicular height.

Surface = $\frac{1}{2}$ of slant height × circumference + base area.

Volume of frustum = volume of cone or pyramid containing frustum minus volume of part cut away.

THE CYLINDER.

Volume = base area multiplied by height.

THE TRIANGLE.

Area = $\frac{1}{2}$ of base multiplied by perpendicular height.

THE ELLIPSE.

Area = long axis × short axis × .7854.

Circumference = $\frac{1}{2}$ long axis + $\frac{1}{2}$ short axis × 3.1416, or $3\frac{1}{7}$.

THE RECTANGLE.

Area = length multiplied by width.

Useful Data for Sheet-metal Workers

Useful Memoranda

A cubic foot of water equals $6\frac{1}{4}$ gallons.
Volume in cubic feet multiplied by $6\frac{1}{4}$ equals gallons.
One gallon equals 277 cubic inches.
Volume in cubic feet multiplied by 25 equals quarts.
Volume in cubic feet multiplied by 50 equals pints.
Volume in cubic inches divided by $69\frac{1}{4}$ equals quarts.
Volume in cubic inches divided by 35 equals pints.
A gallon of water weighs 10 lb.
Weight of hoop iron in lbs. per lineal foot

$$= \frac{\text{width in inches} \times \text{thickness in inches} \times 40.}{12}$$

Thickness of	iron	in ins.	multiplied by	40	=	lbs. per sq. ft.
,,	copper	,,	,,	45	=	,, ,,
,,	brass	,,	,,	44	=	,, ,,
,,	lead	,,	,,	56.8	=	,, ,,
,,	zinc	,,	,,	35.3	=	,, ,,
,,	nickel	,,	,,	48.4	=	,, ,,

NUMBERS, GAUGES, AND APPROXIMATE DIMENSIONS OF RIVETS

Number of Rivets	*Diameters*		*Lengths (Inches)*
	S.W.G.	*Inches*	
5	12	0.1	0.16
6	11	0.11	0.19
7	11	0.11	0.2
8	11	0.11	0.21
9	10	0.125	0.25
10	9	0.135	0.26
11	9	0.14	0.3
12	8	0.15	0.32
13	6	0.18	0.32
14	5	0.2	0.37
15	5	0.2	0.4
16	4	0.22	0.45

Sizes and Capacities of Tanks.—The following tables give the sizes of different tanks and their approximate capacities.

Rectangular Tanks

Gal.	*Length* ft.	*Length* in.	*Width* ft.	*Width* in.	*Depth* ft.	*Depth* in.
10	1	4	1	2	1	1
	1	9	1	0		11
20	1	10	1	4	1	4
	2	0	1	4	1	3
30	2	0	2	0	1	3
	2	0	1	6	1	8
40	2	0	2	0	1	4
	2	3	1	8	1	8
50	2	0	2	0	2	0
	2	5	1	10	1	10
60	2	2	2	2	2	1
	2	6	2	0	2	0
70	2	6	2	3	2	1
	2	8	2	2	2	0
80	2	6	2	6	2	1
	3	0	2	2	2	0
90	3	0	2	5	2	0
	3	0	2	3	2	2
100	3	0	2	6	2	2
	3	2	2	3	2	3

Cylindrical Tanks

Capacity	*Length* ft.	*Length* in.	*Diameter* ft.	*Diameter* in.
1 pt.		4½		3¼
1 qt.		5½		4
3 pt.		6		4½
½ gal.		7		5⅛
1 ,,		8		6¾
5 ,,	1	6		10
10 ,,	1	10	1	1
15 ,,	2	6	1	2
20 ,,	2	4	1	4
25 ,,	2	11	1	4
30 ,,	2	9	1	6
35 ,,	3	3	1	6
40 ,,	3	8	1	6
45 ,,	3	9	1	7
50 ,,	3	9	1	8
55 ,,	3	9	1	9
60 ,,	4	0	1	9
65 ,,	4	0	1	10
70 ,,	3	7	2	0
75 ,,	3	10	2	0
80 ,,	4	2	2	0
85 ,,	3	9	2	2
90 ,,	3	11	2	2
95 ,,	4	2	2	2
100 ,,	4	5	2	2

SIZES OF TIN MEASURES

Measures. in.		in.			Gauge of Wire.
8¾	×	3	=	½ pt.	(15)
10⅞	×	4⅛	=	1 ,,	(14)
13 1/16	×	5¾	=	1 qt.	(12)
17½	×	6⅜	=	2 ,,	(10)
23½	×	7½	=	1 gal.	(8)
28	×	10¼	=	2 ,,	(3/16 in.)
36	×	12	=	4 ,,	(¼ in.)

Useful Data for Sheet-metal Workers

Working edges are allowed for in the above sizes, the approximate gauges of wire for the tops of the measures being bracketed opposite the respective sizes. It is advisable to make one of each, retaining the pattern, and note the working edges required, as different methods of working produce slightly different results.

Sizes of Oil-bottle Bodies.—It should be understood that oil bottles are not intended to be measured, therefore they are usually made to hold more than their stipulated capacities. Bearing this in mind, the following are:

SIZES OF ROUND OIL-BOTTLE BODIES

Approximate Capacity	*Circumference of Body*	*Height of Body*	*Diameter of Body*
1 pt.	10 in.	4½ in.	3⅛ in.
2 ,,	14 ,,	5 ,,	4¼ ,,
3 ,,	15 ,,	5½ ,,	4⅝ ,,
4 ,,	17 ,,	6¼ ,,	5¼ ,,
5 ,,	18½ ,,	6½ ,,	5¾ ,,
6 ,,	20 ,,	6⅝ ,,	6¼ ,,
7 ,,	21½ ,,	6¾ ,,	6⅝ ,,
1 gal.	22½ ,,	7 ,,	7 ,,
2 ,,	26 ,,	9½ ,,	8⅛ ,,
3 ,,	31 ,,	11 ,,	9⅝ ,,
4 ,,	33 ,,	12 ,,	10¼ ,,
5 ,,	38 ,,	12¼ ,,	11⅞ ,,
6 ,,	40 ,,	12½ ,,	12½ ,,

The seam allowances have been deducted before calculating the diameters.

Marks, Gauges, and Thicknesses of Tinplates.—There is probably nothing so confusing to the uninitiated as the markings on the boxes of tinplates. The markings not only indicate the gauges, but also the sizes, and some makers even add to the already long list special marks denoting the quality. The accompanying table shows the

standard marks, gauges, and thicknesses of tinplates. One maker uses C L and a crown to indicate extra double tinned charcoal sheets interleaved with tissue paper, while another maker uses A, B, and C to denote qualities termed "Best Best," "Best," and "Common" charcoal plates respectively. Referring to the table, it may be mentioned that the first seven may be obtained in sizes 28 in. by 20 in., or 20 in.

MARKS, GAUGES, AND THICKNESSES OF TINPLATES

Mark on Box	*Gauge (B.W.G.)*	*Thickness (Inch)*
1 C	30	.012
1 ×	28	.014
1 × ×	27	.016
1 × × ×	26	.018
1 × × × × ..	25	.020
1 × × × × × ..	24	.022
1 × × × × × ×	22 easy	.027
D C	28 full	.015
D ×	26	.018
D × ×	25	.020
D × × ×	24	.022
D × × × × ..	22	.028
D × × × × × ..	21	.032
D × × × × × ×	20	.035
S D C	28 full	.015
S D ×	26	.018
S D × ×	25	.020
S D × × × ..	24	.022
S D × × × × ..	24 full	.023
S D × × × × × ..	23	.025
S D × × × × × ×	22 full	.029

by 14 in. The next seven may be obtained in sizes 25 in. by 17 in. or 17 in. by 12½ in., while the last seven may be obtained in sizes 22 in. by 15 in., or 15 in. by 11 in. Formerly tinplates were referred to as "Singles," "Middles," and "Doubles." The "Singles" measured 14 in. by 10 in.,

the "Middles" 15 in. by 11 in., and the "Doubles" 17 in. by $12\frac{1}{2}$ in. By comparing these sizes with those previously given, it will be seen that the superficial measurements of the present tinplates are either twice or four times as much as formerly. Thus a 28-in. by 20-in. sheet contains four "Singles," while a 20-in. by 14-in. contains two. A 22-in. by 15-in. contains two "Middles," and a 25-in. by 17-in. sheet contains two "Doubles." The number of plates in a box varies from 50 to 225, according to size and quality.

Calculating Capacities of Cylindrical and Conical Vessels.—The capacity of a cylindrical vessel may be obtained by multiplying the area of the base by the height. If the answer is in cubic feet, multiply it by $6\frac{1}{4}$ to bring it to gallons. If the answer, however, is in cubic inches, divide it by 277 to bring it to gallons, or by 70 to bring it to quarts, or by 35 to bring it to pints. To find the height of a cylinder of stated cubic capacity when the diameter is known, divide the area of the base of the cylinder into the cubic contents. Thus, supposing the height of a cylinder to hold 3 pt. is required when the diameter is 5 in. The area of a 5-in. circle is 19.6 sq. in., and there are 105 cub. in. in 3 pt. Therefore $105 \div 19.6 = 5.35$ in., the height required. Working edges, of course, would be additional. The capacity of a conical vessel may be obtained by multiplying the area of the base by the upright height of the cone and dividing by 3, or, Capacity = area of base $\times$ $\frac{1}{3}$ upright height of cone. The capacity of a frustum can be obtained by subtracting the capacity of the cone cut away from the complete cone. Thus assuming that AB = $4\frac{1}{2}$ in., AC = 7 in., and CD = 6 in., then—

$$\left.\begin{array}{c}\text{Capacity of}\\ \text{complete}\\ \text{cone}\end{array}\right\} = \underbrace{(\text{Area of CD})}_{28\cdot2} \times \overset{(ob)}{\underbrace{(\text{upright height})}_{26\cdot5}} \div 3 = \begin{array}{c}\text{cubic inches}\\ 249.1\end{array}$$

$$\left.\begin{array}{c}\text{Capacity of}\\ \text{cut-away}\\ \text{cone.}\end{array}\right\} = \underbrace{(\text{Area of AB})}_{15\cdot9} \times \overset{(oa)}{\underbrace{(\text{upright height})}_{19\cdot5}} \div 3 = 103.3$$

$$\therefore \text{Capacity of frustum (ABCD)} = \underline{\overline{145.8}}$$

Dividing this latter figure by 35 to bring it to pints, we get 145.8 ÷ 35 = 4.16 (practically 4 pt.). Of course, if the cans under consideration are not intended to be measures, they should be capable of carrying their rated capacities and at the same time allow for the more or less free move-ment of the liquid contents. Bearing this in mind, and remembering that the wiring edge for the top, and an edge for a knocked-up bottom, will reduce the capacity, the example should serve for a 3-pt. can. If preferred, the worker can decide what excess to allow on the various sizes; the calculation can then be made, and the working edges added. In order to get the various sizes "proportionate," the relation of the slant depth to the base should be noted. A cone should then be drawn to scale (say 1 in. to 1 ft.) as here shown, where the slant depth is equal to $1\frac{1}{6}$ times the base. The cone can then be divided, as indicated, or other divisions may be drawn, from which the necessary calculations can be made. These divisions may overlap each other if a large range of sizes is required; but this is immaterial; the chief point is to retain the ratio between the slant depth and the base. Acting on the foregoing instructions, a workman could calculate a range of sizes to meet his requirements, and then set out a pattern for each, which should be duly marked and retained for subsequent use.

GAUGES, THICKNESSES, AND WEIGHTS OF BLACK SHEET IRON AND STEEL

Gauge number	*Thickness*		*Weight*						
	Inches	*Millimetres*	*Per sheet 72 × 24 in.*		*Per sheet 72 × 30 in.*		*Per sheet 72 × 36 in.*		*Per sq. ft.*
			qrs.	*lbs.*	*qrs.*	*lbs.*	*qrs.*	*lbs.*	*lbs.*
10	.125	3.175	2	14	3	4	3	21	$5\frac{5}{8}$
11	.111	2.827	2	4	2	19	3	6	5
12	.099	2.517	1	26	2	12	2	25	$4\frac{1}{2}$
13	.088	2.240	1	20	2	4	2	16	4
14	.078	1.994	1	13	1	23	2	5	$3\frac{3}{8}$
15	.069	1.775	1	8	1	17	1	26	3
16	.062	1.587	1	2	1	10	1	17	$2\frac{1}{2}$
17	.055	1.412		27	1	6	1	13	$2\frac{1}{4}$
18	.049	1.257		24	1	2	1	8	2
19	.044	1.118		21		26	1	3	$1\frac{3}{4}$
20	.039	.996		18		23		27	$1\frac{1}{2}$
21	.034	.886		16		21		25	$1\frac{3}{8}$
22	.031	.794		15		19		23	$1\frac{1}{4}$
23	.027	.707		14		17		20	$1\frac{1}{8}$
24	.024	.629		12		15		18	1
25	.022	.560		11		13		16	14 oz.
26	.019	.498		10		12		14	13 oz.
27	.017	.443		8		10		12	$10\frac{3}{4}$ oz.
28	.015	.396		7		9		$10\frac{3}{4}$	$9\frac{1}{2}$ oz.
29	.013	.353		6		$7\frac{1}{2}$		$9\frac{1}{4}$	$8\frac{1}{4}$ oz.
30	.012	.315		$5\frac{1}{2}$		$6\frac{1}{2}$		$8\frac{1}{2}$	$7\frac{1}{2}$ oz.

To obtain the weight in lbs. per sq. foot of iron plates, multiply the thickness in inches by 40.